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BEFORE THE ARIZONA CORPORATION COMMISSION

COMMISSIONERS

TOM FORESE, Chairman
BOB BURNS
DOUG LITTLE
ANDY TOBIN
BOYD DUNN

IN THE MATTER OF THE APPLICATION OF ARIZONA PUBLIC SERVICE COMPANY FOR A HEARING TO DETERMINE THE FAIR VALUE OF THE UTILITY PROPERTY OF THE COMPANY FOR RATEMAKING PURPOSES, TO FIX A JUST AND REASONABLE RATE OF RETURN THEREON, TO APPROVE RATE SCHEDULES DESIGNED TO DEVELOP SUCH RETURN.	DOCKET NO. E-01345A-16-0036 **ARIZONA PUBLIC SERVICE COMPANY'S NOTICE OF FILING**
IN THE MATTER OF FUEL AND PURCHASED POWER PROCUREMENT AUDITS FOR ARIZONA PUBLIC SERVICE COMPANY.	DOCKET NO. E-01345A-16-0123

APS provides notice that it is filing the attached settlement rebuttal testimonies of Ms. Barbara Lockwood, Mr. Leland Snook, Mr. Charles Miessner, and Mr. Scott Bordenkircher as Exhibits 1-4, respectively.

RESPECTFULLY SUBMITTED this 17th day of April 2017.

By: _____
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Exhibit 1

SETTLEMENT REBUTTAL TESTIMONY OF
BARBARA D. LOCKWOOD
On Behalf of Arizona Public Service Company
Docket Nos. E-01345A-16-0036 & E-01345A-16-0123

April 17, 2017

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SETTLEMENT REBUTTAL TESTIMONY OF BARABRA D. LOCKWOOD
ON BEHALF OF ARIZONA PUBLIC SERVICE COMPANY
(Docket Nos. E-01345A-16-0036 & E-01345A-16-0123)

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME, ADDRESS, AND OCCUPATION.

A. My name is Barbara D. Lockwood. My business address is 400 North 5th Street, Phoenix, Arizona, 85004. I am Vice President of Regulation for Arizona Public Service Company (APS or Company). I have management responsibility for all matters before the Arizona Corporation Commission (Commission), as well as, the Federal Energy Regulatory Commission (FERC).

Q. DID YOU PREVIOUSLY FILE SETTLEMENT TESTIMONY IN THIS MATTER?

A. Yes.

Q. WHAT IS THE PURPOSE OF YOUR SETTLEMENT REBUTTAL TESTIMONY?

A. My Settlement Rebuttal Testimony addresses certain arguments raised by intervenors in their Direct Settlement Testimony and highlights why, notwithstanding their testimony, the Settlement Agreement in this proceeding is in the public interest and should be approved without material modification. I do not address each issue raised by the intervenors. APS witnesses Leland Snook, Charles Miessner, and Scott Bordenkircher also address various aspects of the parties' settlement testimony.

II. SUMMARY

Q. PLEASE SUMMARIZE YOUR SETTLEMENT REBUTTAL TESTIMONY.

A. My testimony discusses discrete aspects of several parties' direct settlement testimony. First, I explain that the adjustment for the Resource Comparison Proxy of $0.02/kWh is not based on a calculation of actual system conditions, nor does it reflect anything other than a negotiated settlement to resolve this proceeding, contrary to the testimony of EFCA's James Heidell. I also demonstrate that the Settlement Agreement directly

resolved what DG customers will be paid for exported energy after 10 years, despite the assertions made by SEIA's Sara Birmingham.

I also discuss concerns raised by several non-settling parties. In response to AARP and SWEEP, my testimony highlights that the 90-day trial period strikes the right balance between modernizing rate design and permitting customers the option of selecting basic rates. By taking service under a time-of-use or demand rate for 90 days, new customers will be exposed to and become familiar with more modern rates. Although these customers have the option to return to basic rates, this 90-day trial will also give them the opportunity to reduce their bills and lower system costs by responding to price signals. I also explain that APS welcomes stakeholder feedback on the transition plan to this new rate structure, but has serious reservations about a "transition plan by committee" as suggested by AARP.

In response to concerns about the Settlement BSCs, my testimony explores the rationale behind BSCs, and that they not only enhance customer bill and utility revenue stability, but also fairly apportion cost according to causation. Moreover, the Settlement BSCs, which range between $10 - $15 for most customers, reflect a compromise of positions—they are not as high as APS's requested $24, but not as low as SWEEP's proposed $8.

Finally, my testimony explores a few unrelated concerns raised by different witnesses:

- That the $15 million refund of collected DSM funds is an opportunity to reduce the first year impact of this rate case and return customer money now, rather than wait to refund the money until some undetermined time (SWEEP);

- The settlement process was fair and demonstrates the value of collaborating to resolve complicated policy issues through settlement, rather than litigating those issues and forcing binary, "win/lose" outcomes (ED-8/McMullen);

- The Settlement's AMI policy is not discriminatory, but instead appropriately reflects actual cost differences between serving AMI and non-AMI customers (Warren Woodward); and,

- Staff's fuel audit offers many excellent recommendations for strengthening APS's fuel program, but one of audit recommendations should be postponed until APS can implement all suggested changes, and another recommendation should be modified to permit flexibility for system-reliability purposes.

III. COMMENTS ON SETTLING PARTIES' TESTIMONY

Q. DOES THE NEGOTIATED FIRST YEAR RCP RATE HAVE MEANING BEYOND THE SETTLEMENT AGREEMENT?

A. No, it does not. In his Direct Settlement Testimony, EFCA witness James Heidell states that the $0.02/kWh adjustment to the RCP rate "indicates that the parties acknowledge that distributed solar does provide value to those components of the system." This statement, however, is inaccurate and directly contrary to the parties' Agreement.

The RCP Plan of Administration—a document that was part of the parties' negotiation—specifically addresses the nature of the $0.02/kWh adjustment, stating that the "amount is negotiated, does not reflect an actual calculation of system conditions, and establishes no precedent for any future RCP or avoided cost calculations."[1] This is consistent with Paragraph 18.4 of the Settlement Agreement, which provides that the first year export rate was "the product of settlement negotiations and [did] not create any precedent, imply any change to the structure of or detail in the Resource Comparison Proxy, or otherwise change any aspect of Decision No. 75859" and Paragraph 40.3 of the Agreement, which provides that none "of the positions taken in [the] Agreement by any of the Signing Parties may be referred to, cited, or relied upon as precedent before

[1] RCP Plan of Administration at 6.

the Commission, any other regulatory agency, or any court for any purpose except to secure approval of [the] Agreement and enforce its terms."

Given that the $0.02/kWh adjustment "does not reflect an actual calculation of system conditions," and "establishes no precedent for any future RCP or avoided cost calculations," it cannot be fairly said that the $0.02/kWh adjustment has any meaning whatsoever outside this Agreement.

Q. SEIA TESTIFIED THAT THE RATE FOR EXPORTED SOLAR ENERGY AFTER 10 YEARS IS UNRESOLVED; DO YOU AGREE?

A. SEIA witness Sara Birmingham testified that the Agreement did not "provide transparency with respect to the export rate that customers will receive at the end of the 10-year RCP payment period" and that SEIA looks forward to working with stakeholders on providing more transparency and predictability for the rate in that post 10-year period. However, the Agreement did address and resolve the export rate after the 10 year RCP period. Both the RCP Rate Rider and the RCP Plan of Administration state that "After each Customer's initial 10 year period the bill credit will be based on the purchase rate in effect at the time, and may change from year to year."[2]

As with all issues in the Agreement, this issue was part of the parties' negotiations, and this language forms a part of the basis upon which all parties were willing to accept the Agreement. I am certain that SEIA negotiated in good faith, and is not now expressing any intent to immediately seek a change to the terms of the Agreement. Given that certainty, I believe that SEIA is interested working with stakeholders in anticipation of APS's next rate case, which is when the terms of the Agreement no longer bind the parties.

[2] Rate Rider RCP at 1; RCP Plan of Administration at 2.

IV. COMMENTS ON NON-SETTLING PARTIES' TESTIMONY

Q. CERTAIN NON-SETTLING PARTIES DISAGREE WITH THE 90-DAY RATE TRIAL PERIOD. PLEASE COMMENT.

A. Section 19 of the Agreement provides that new residential customers taking service after May 1, 2018 may take service under R-Basic after first taking service under a time-of-use or demand rate for 90 days. A few non-settling parties, such as SWEEP and AARP, contest this provision, stating that customers should be able to take service under R-Basic without waiting for 90 days.

APS' original proposal was to broadly modernize rates by implementing demand rates for all but our smallest customers. This Agreement does not involve universal demand rates nor does it even take the interim step of implementing universal time-of-use rates. While APS would still have preferred to eliminate the antiquated R-Basic design, not all parties agreed and in the spirit of compromise, we negotiated a method of allowing existing customers to keep a Basic rate while taking a step towards more modern rate design by establishing a 90-day trial period for new customers.

Having customers briefly try a time-of-use or demand rate, however, is an important part of modernizing APS's rate design. The time-of-use and demand rates detailed in the Agreement would send appropriate price signals to customers to use electricity more efficiently, at times when supply is higher and demand is lower. As discussed in Mr. Miessner's Settlement Rebuttal Testimony, more modern rates do not necessarily translate to higher bills. In fact, if customers decide to respond to those price signals, they will lower system costs for all customers and save money for themselves.

Q. DOES THE AGREEMENT PROVIDE OTHER PROTECTIONS RELATED TO THE 90-DAY TRIAL PERIOD?

A. Yes. The 90-day trial period does not apply to the smallest customers—those consuming less than 600 kWh per month. In addition, under the Agreement, APS will create and

file a customer outreach and education plan designed to help customers learn about their new rate options, which will include services and tools that can help them manage their utility costs.

Q. DO YOU AGREE WITH AARP'S SUGGESTION THAT ANY TRANSITION PLAN SHOULD BE DEVELOPED COLLABORATIVELY?

A. APS is always interested in hearing from engaged stakeholders, and welcomes helpful suggestions. APS will even commit to discussing the transition plan with stakeholders before implementation. In APS's experience, however, developing customer-facing materials and messages "by committee" almost never works, and more often than not, stalls the process entirely. This is not because any one participant seeks to undermine the process, but rather that participants typically have firmly-held beliefs about numerous aspects that can not be reconciled with other participants' perspectives, and reconciliation becomes impossible. APS welcomes engaged input from interested stakeholders and will actively solicit that input before finalizing its transition plan.

Q. DO THE CONCERNS ABOUT BASIC SERVICE CHARGES ACCURATELY CHARACTERIZE THE PURPOSE AND IMPORTANCE OF REASONABLE FIXED CHARGES?

A. No, the concerns about monthly BSCs expressed by a few parties do not appear to provide the entire picture about their role and importance in rate design. As with all aspects of setting rates for utilities, rate design is typically most successful when it balances all interests. APS agrees that conservation is one desirable goal of rate design. Economic efficiency is another. In fact, the pursuit of these two principles is a significant reason why the time-of-use and demand rates proposed by the Agreement are in the public interest. Other principles underlie the importance of BSCs as well, including revenue and rate stability, and fair cost apportionment amongst customers.

BSCs provide utilities a degree of revenue stability. They also reduce month-to-month variations in overall bill levels because more of the revenue to be collected is placed into the fixed charge. And to the extent BSCs reflect actual fixed costs, they significantly

improve the chances that rate design accurately assigns cost responsibility to cost causation. This latter consideration also promotes economic efficiency rather than impedes it precisely because prices are better aligned with costs.

In this proceeding, APS proposed BSCs of up to $24 per month for many of APS's customers. But under the Agreement, over half of APS's customers will see their BSCs *decrease* approximately 24% from $16.91 to $13 per month. The Agreement does increase BSCs for the other half of APS's customers from their current monthly charge of $8.67 per month. This is a particularly low BSC, however, and viewed in the aggregate, the Agreement largely moves APS's BSCs "to the middle"—away from the extreme lows of $8.67, but not up to APS's proposal of $24. In addition, the perception that higher BSCs cause higher bills is incorrect, as discussed in APS Witness Miessner's Settlement Rebuttal Testimony.

Another strategy with respect to the BSC proposal is to encourage customers to adopt more modern rates by decreasing the BSC for the time-of-use and demand rates. This is one of the primary reasons for the decrease from R-Basic at $15 per month to the time-of-use and demand rates at $13 per month.

Given the multi-faceted principles underlying rate design, and the importance of BSCs in achieving rate and revenue stability, and fairly apportion cost, APS strongly believes that the Agreement reflects a balanced approach to fixed charges and is in the public interest.

Q. DOES APS BELIEVE THAT THE PROPOSED REFUND OF DSM FUNDS IS REASONABLE, DESPITE SWEEP'S CONCERNS?

A. Yes, absolutely. The overcollected funds should be refunded to customers, and there is no compelling reason to keep the money from customers. SWEEP notes that the Commission approved a smoothed year-to-year compliance plan for APS's DSM savings goal, and identified using the overcollected funds in connection with that

smoothed compliance as one option. The Commission did not, however, mandate how the overcollected funds should be used. Refunding the overcollected funds now would mitigate the first year impact of the rate increase proposed by the Agreement, and could effect a form of rate gradualism by causing the rate increase to be functionally implemented in two phases. The Signing Parties have agreed that this is reasonable and in the public interest to refund the money now, and have proposed doing so. The Commission now can decide the issue and do what it believes is in the public interest.

Q. ED-8/MCMULLEN VALLEY EXPRESSED GENERAL CONCERNS ABOUT THE SETTLEMENT. DOES APS HAVE A PERSPECTIVE ON THIS TOPIC?

A. We do. The settlement process was conducted over a period of almost three months with numerous in-person meetings and more telephonic meetings on select issues. Every party, including ED-8/McMullen, was afforded numerous opportunities to state their position and advocate for an outcome. We believe the process was fair and resulted in more balanced outcomes than likely could have been achieved through a protracted litigation. Litigation is wasteful, and relying on litigation to resolve complicated public policy issues can result a binary outcome or at best a series of binary outcomes that only reflect one side's perspective. Settlements, on the other hand, are often good public policy. They avoid protracted hearings that can often add little incremental value to the factual record. Settlements also permit parties to collaboratively develop unified positions for Commission consideration, rather than rely on a judge to order relief within the limited parameters permitted by law.

In this proceeding, the settlement process fell within the typical pattern of contested matters. In the 29 years that ED-8/McMullen Valley witness James Downing has been in the electric industry, he has surely seen parties hire qualified experts, who in turn offer widely divergent and firmly held opinions, only to have those parties settle near the middle. Parties typically settle for various reasons, including risk of litigated outcomes and in the interest of preserving both resources and relationships.

This proceeding involved similar considerations. And even parties that oppose the Settlement, such as SWEEP, "found the settlement discussions to be open, transparent, and inclusive of all parties who desired to participate."[3] APS very much appreciates all parties' participation in this open and transparent process, including ED-8/McMullen's participation, and appreciates the sacrifices and concessions that parties made to reach the negotiated resolution reflected in the Agreement.

Q. INTERVENOR WARREN WOODWARD ASSERTS THAT THE SETTLEMENT AGREEMENT'S TERMS REGARDING AMI DISCRIMINATE AGAINST CUSTOMERS IN VIOLATION OF ARIZONA LAW. DO YOU AGREE?

A. I am not a lawyer and cannot offer a legal opinion. I will note, however, that the statute Mr. Woodward cites to support his assertion—A.R.S. § 40-334—only proscribes public service corporations from establishing or maintaining any "unreasonable difference as to rates, charges, service, facilities or in any other respect, either between localities or between classes of service." If the law did not permit "reasonable" differences between how different customers are charged, public service corporations would be required to charge residential and non-residential customers the same rate.

When customers voluntarily decide to opt-out of AMI, APS incurs more cost to provide the same level of service that APS provides to customers with AMI. APS believes that it is reasonable to assign some of that additional cost to these customers—consistent with the rate-making principle of cost causation—even if the cost assigned is the modest $50 upfront fee and $5 monthly fee provided for in the Agreement.

The Commission must ultimately determine whether this cost-causation difference between AMI and non-AMI customers is in fact sufficient to justify the modest difference in charges.

[3] SWEEP Settlement Direct Testimony of Jeff Schlegel at 2.

V. FUEL AUDIT

Q. DOES APS HAVE ANY COMMENTS OR CONCERNS REGARDING THE RECOMMENDATIONS IN STAFF'S FUEL AUDIT?

A. APS very much appreciates the hard work Commission Staff has exhibited in connection with the fuel audit. The audit requires obtaining and evaluating a large quantity of detailed data, and it is clear that a thorough and complete audit was conducted.

APS is also satisfied with the results. The audit did not find any significant areas of concern in APS's management or financial activities, nor regarding APS's Plan of Administration for its Power Supply Adjustor mechanism. The audit did propose six recommendations, primarily focused on improving documentation. APS appreciates the external review of its processes and welcomes Staff's constructive suggestions.

There are two recommendations, however, that APS would like to offer commentary on. First, Recommendation III-2 proposes that internal or external auditors audit APS's PSA filings. APS agrees that an internal or external audit of this nature could be helpful, but suggests that the audit be delayed for 18 months to allow APS time to implement the other recommendations in the fuel audit. With enough time to fully implement Staff's other recommendations, Staff's proposed audit would be a good opportunity to assess how those recommendations have been implemented.

Second, Recommendation III-5 proposes that APS change how it treats counterparties that are overexposed. Whether a counterparty's credit becomes too limited or for some other reason, counterparties can at times become overexposed, increasing the risk that they may not be able to fulfill payment or other contractual obligations. The Fuel Audit recommends that APS traders be notified of overexposure on a daily basis, and that

APS's system be immediately reconfigured to disallow transactions with the overexposed counterparty.

Requiring APS's system to immediately disallow transactions with a particular counterparty, however, is inconsistent with best practices. At times, APS must transact with a particular party, even if they are overexposed, for critical system-related reasons, such as a need to preserve system reliability. In that circumstance, the need for reliability must trump the possibility that an overexposed party might not fulfill the contract. In addition, APS sees the risk of non-payment as low, and is able to mitigate that risk with different mechanisms, such as fuel hedging or even insurance, when appropriate.

APS understands the importance of credit limits. Indeed, the Fuel Audit lauds APS's system for credit evaluation. But an automatic process for terminating transactions with a particular counterparty without regard for system conditions violates industry best practices. APS needs the operational flexibility to transact with any counterparty and manage the risk of non-payment by other means. In APS's opinion, Recommendation III-5 should not be implemented as stated at this time.

VI. CONCLUSION

Q. DOES THIS CONCLUDE YOUR WRITTEN SETTLEMENT REBUTTAL TESTIMONY?

A. Yes.

Exhibit 2

SETTLEMENT REBUTTAL TESTIMONY OF LELAND R. SNOOK

On Behalf of Arizona Public Service Company

Docket Nos. E-01345A-16-0036 & E-01345A-16-0123

April 17, 2017

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SETTLEMENT REBUTTAL TESTIMONY OF LELAND R. SNOOK
ON BEHALF OF ARIZONA PUBLIC SERVICE COMPANY
(Docket Nos. E-01345A-16-0036 & E-01345A-16-0123)

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME, ADDRESS, AND OCCUPATION.

A. My name is Leland R. Snook. My business address is 400 North 5th Street, Phoenix, Arizona, 85004. I am Director of Rates and Rate Strategy for Arizona Public Service Company (APS or Company). I have management responsibility for all aspects relating to rate strategy and specific rates and prices.

Q. DID YOU PREVIOUSLY FILE SETTLEMENT TESTIMONY IN THIS MATTER?

A. Yes. I filed Direct Settlement Testimony in this docket on April 3, 2017.

Q. WHAT IS THE PURPOSE OF YOUR SETTLEMENT REBUTTAL TESTIMONY IN THIS PROCEEDING?

A. The purpose of my Settlement Rebuttal Testimony is to address the Direct Testimony of two witnesses: 1) James D. Downing on behalf of Electrical District Number Eight (ED8) regarding the Ocotillo Modernization Project (OMP) and other Company specific information; and 2) Jeff Schlegel on behalf of Southwest Energy Efficiency Project (SWEEP) with respect to his testimony on Basic Service Charges (BSC) agreed to by settling parties in the Settlement.

II. SUMMARY

Q. PLEASE SUMMARIZE YOUR TESTIMONY.

A. Mr. Downing has mischaracterized the OMP and its purpose. Without refuting every flaw in Mr. Downing's testimony, the load figures quoted include a large long-term wholesale transaction that terminated during the period and Mr. Downing does not account for the fact that APS has a number of long-term purchase agreements that are expiring. Further, Mr. Downing fails to recognize that APS has closed almost 800 MW of coal-fired resources during the period of his comparison. The OMP is a unique, fast-ramping, flexible resource that can be started and stopped multiple times per day, if

necessary, and can reach its full production capability very fast compared to traditional generating units. This type of flexible resource is critical in the world we live in now with a myriad of non-dispatchable intermittent renewable resources connected to the grid. The phenomenon of the duck curve, which is discussed in more detail by APS witness Charles Miessner in his Direct Settlement testimony, did not exist in 2008, but is real today and getting more pronounced year by year. The OMP will be a critical tool in modernizing the grid to reliably keep the lights on for APS's customers.

I also address Mr. Schlegel's testimony on BSCs, which ignores the purpose behind the BSC proposal in the Settlement; BSCs should be higher for basic rates and lower for more modern rates as a way of encouraging customers to try more modern rates. Further, the method to derive BSCs employed by Mr. Schlegel is the floor for a BSC, not the ceiling. Policy goals guide each jurisdiction on where to establish the BSC within reasonable boundaries. Mr. Schlegel also incorrectly states that the majority of APS's residential customers will see increased BSCs. In fact, the opposite is true - the Settlement actually reduces BSCs by approximately $4 per month or 24% for over half of APS's customers.

III. OCOTILLO MODERNIZATION PROJECT

Q. IS MR. DOWNING'S PERSPECTIVE ON THE OMP ACCURATE?

No. Mr. Downing mischaracterizes the purpose of the OMP. While the OMP will certainly allow APS to meet its peaking resource needs, it is a fast-ramping, flexible resource that can reach full generating capability in a very short time. This new type of resource is necessary in the changing utility landscape of today and is a critical component of a modern grid. In addition, the OMP modernizes outdated generation technology in a location within the electric system that provides APS unique operational benefits to serve its customers. The presence of existing gas and electrical transmission infrastructure at the Ocotillo site further enhances this project's value. It is also important to note that the costs for OMP are not being agreed to as part of the

Settlement. Rather, the Settlement provides for an accounting deferral order which would defer the costs of OMP for potential recovery by APS in the future. The prudence of OMP will be addressed in a future docket.

Q. ARE THERE OTHER FLAWS IN MR. DOWNING'S TESTIMONY?

A. Yes. Mr. Downing compares peak demand data from 2008 to more recent data, but fails to account for the fact that APS had a large wholesale transaction with another utility in the state, Electrical District Number 3, expire during this period. In addition, Mr. Downing does not account for the fact that APS has several wholesale purchase agreements expiring, and APS has retired almost 800 MW of coal-fired resources during this period of time. APS must have adequate resources to reliably serve its customers. Peak demands of APS's retail customers are a component of this analysis, but the resource mix on the resource side of the equation is also dynamic, rather than static.

In addition, several of the "metrics" proposed by Mr. Downing do not use appropriate data comparators and/or are not representative of the appropriate data. Using actual APS rate case test year data from similar periods of time, I conclude Mr. Downing's analysis is flawed. For example, Mr. Downing states depreciated plant nearly doubled from 2004 to 2015, from $6.3 billion to $12 billion. While this is true, it is not an appropriate comparison for rate making. For example, APS's as-filed adjusted test-year Total Company rate base in the 2007 test-year was $6.236 billion and is $8.012 billion in this case. This is the comparison to make in the context of establishing just and reasonable rates. It starts with net utility plant and subtracts deductions for items such as deferred taxes, asset retirement obligations, pension and regulatory liabilities; and adds regulatory and pension assets, decommissioning trust accounts and an allowance for working capital. Similarly, APS's adjusted test-year retail revenue in 2007 was $2.690 billion and total adjusted retail sales were 28,855,123 MWh ($93.22 per MWh) and is $2.933 billion on adjusted retail sales of 28,015,615 MWh in this case ($104.69 per

MWh). In sum, Mr. Downing's statistics are either inaccurate or not directly related to the conclusions he posits.

IV. TESTIMONY OF SWEEP

Q. DOES SWEEP HAVE A PHILOSOPHY BEHIND ITS BSC RECOMMENDATIONS?

A. SWEEP's witness Mr. Schlegel contends that all BSCs should be low, all the time, to encourage energy conservation. But Mr. Schlegel's view is one-dimensional. There are other purposes to rate design. The role played by the BSC should consider factors other than just the impact on energy conservation. For example, the Settlement Agreement adopted the philosophy, which this Commission established in the recent UNS Electric rate case, that basic rate designs should have higher BSCs and more modern rate designs should have lower BSCs as a way of encouraging customers to try more modern cost reflective, rate structures. In APS's case, Mr. Schlegel also ignores the starting point that exists in APS's present residential rates, where over half of APS's residential customers are on more modern rates today and pay approximately $16.91 per month in a BSC. APS's basic rates today have a BSC of $8.67 per month. The Settlement adopted a $10 BSC for the smallest customers on basic rates, but adopted $15 and $20 for larger customers on basic rates. These larger customers on basic rates would, in most cases, save money by signing up for a more modern time-of-use (TOU) energy or demand rate. The Settlement reduced the BSCs for the majority of APS's residential customers who are presently on TOU energy and demand rates by $4 per month, or approximately 24%, to $13 in order to establish this philosophical goal as residential rate design evolves.

Q. MR. SCHLEGEL CONTENDS THAT THE SETTLEMENT BSCS ARE NOT COST JUSTIFIED. PLEASE EXPLAIN THE FLAW IN MR. SCHLEGEL'S CONTENTION.

A. Mr. Schlegel suggests that it is only appropriate to include basic customer costs in BSCs, which he defines as meters, billing, meter reading and customer service. The inference is that any costs beyond these costs are not cost justified. However, all of APS's costs are cost justified in a rate case. The BSC is one billing component that can

be used to recover these justified costs. A number of other factors could certainly support much higher BSCs. Mr. Schlegel also states that his proposal is consistent with Mr. Bonbright on this topic, but Bonbright defines customer costs as:

> "...those operating and capital costs found to vary with the number of customers, regardless, or almost regardless, of power consumption. Included as a minimum are the costs of the drop wire, metering and billing, along with whatever other nonrecoverable expenses the company must incur in taking on another consumer."

Bonbright's definition is much broader than that proposed by Mr. Schlegel. For example, Mr. Schlegel excludes the service drop, which is in the minimum definition from Bonbright. In addition, it is not unreasonable to include a portion of the cost of a customer information system in the BSC or the pole or pad-mounted transformer near the customer's home. All of these costs are part of the cost of the service drop and may properly be included in the BSC because they are incurred to serve a customer irrespective of the volume of energy they consume.

V. CONCLUSION

Q. DO YOU HAVE ANY FINAL COMMENTS?

A. Yes. The Commission should adopt the Settlement Agreement as written. The Commission should reject the testimony of Mr. Downing, because it is an inaccurate characterization of the OMP and what the Settlement Agreement provision related to an accounting deferral order on OMP actually provides. The Commission should reject Mr. Schlegel's testimony on the Settlement Agreement BSCs. There was a guiding philosophy behind the BSCs adopted in the Settlement Agreement and further, Mr. Schlegel advocates for a BSC methodology that does not meet the minimum threshold for cost causation. The Settlement Agreement as originally crafted is in the public interest and should be approved by the Commission.

Q. DOES THIS CONCLUDE YOUR SETTLEMENT REBUTTAL TESTIMONY?

A. Yes.

Exhibit 3

SETTLEMENT REBUTTAL TESTIMONY OF CHARLES A. MIESSNER

On Behalf of Arizona Public Service Company

Docket Nos. E-01345A-16-0036 & E-01345A-16-0123

April 17, 2017

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SETTLEMENT REBUTTAL TESTIMONY OF CHARLES A. MIESSNER
ON BEHALF OF ARIZONA PUBLIC SERVICE COMPANY
(Docket Nos. E-01345A-16-0036 & E-01345A-16-0123)

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME, ADDRESS, AND OCCUPATION.

A. Charles A. Miessner, 400 North Fifth Street, Phoenix, Arizona 85004. I am Manager of Rates for Arizona Public Service Company (APS or Company).

Q. DID YOU PREVIOUSLY FILE SETTLEMENT TESTIMONY IN THIS MATTER?

A. Yes.

Q. WHAT IS THE PURPOSE OF YOUR SETTLEMENT REBUTTAL TESTIMONY IN THIS PROCEEDING?

A. I address certain positions and recommendations related to rate design made by parties that are not signatories to the Settlement Agreement ("Settlement" or "Agreement") and explain why the compromise positions agreed to by the settling parties are fair and beneficial. I also rebut positions by certain settling parties on the issue of the ratchet feature for rate E-32L for large commercial and industrial customers, which the Settling Parties agreed to further contest in this proceeding.

Specifically, I address the following issues:

- The monthly basic service charges (BSCs) for residential rates;
- The new on-peak hours for time-of-use (TOU) rates;
- The 90-day trial provision for residential rate R-Basic; and
- The ratchet provision for rate E-32L

II. SUMMARY

Q. WILL YOU PLEASE SUMMARIZE YOUR SETTLEMENT REBUTTAL TESTIMONY?

A. In my Settlement Rebuttal Testimony, I explain and support the following rebuttal positions:

- **The Settlement BSCs for residential rates are fair.** The residential BSCs proposed in the Settlement are fair and represent a compromise position. SWEEP's and AARP's claims and recommendations to the contrary are inaccurate, unsupported by evidence, and therefore, should not be adopted. SWEEP's and AARP's specific claim that the Settlement will result in significantly higher BSCs for most residential customers is simply inaccurate. In actuality, the Settlement results in significantly lower BSCs for over half of residential customers and a very modest $1.33 per month increase for about 25% of residential customers.

- **The new TOU rates have reduced on-peak hours, which better reflect times of high system peaks and costs yet balance individual customer interests.** The revised TOU on-peak hours of 3 p.m. to 8 p.m. weekdays, excluding 10 holidays, is a significant reduction from the two current TOU rates, which have 12-hour and 7-your on-peak periods respectively. The revised on-peak hours balance the need to reflect time of high system peaks and costs with individual customer interests for peak periods that are reasonably short.

  SWEEP's proposal that the on-peak period should be even further reduced to 3 hours, rather than the proposed 5-hour period, is unsupported by any evidence and is inconsistent with APS's times of high peak loads and costs. The record actually supports a 3 p.m. to 9 p.m. on peak period but in the interest of customers' desire for shorter periods, APS initially proposed and continues to

support the 3 p.m. to 8 p.m. on peak period. Any shorter time period could result in customers shifting usage from one peak hour to another peak hour, rather than to the off-peak period. For these reasons SWEEP's recommendation should not be adopted.

- **The Settlement's implementation plan for residential flat rate R-Basic is a balanced approach with customer benefits**. The plan, which provides general availability to the flat two-part rates through a transition period and continued availability after a 90-day trial on a TOU or demand rate, after the transition period, balances the objective of encouraging customers to move to a TOU rate, while maintaining customer access to a basic rate.

  Opinions by SWEEP and AARP that customers should be offered unrestrictive access to these outmoded two-part basic rates indefinitely would likely impede the progress towards rate reform that is contemplated by the Settlement. SWEEP and AARP want to preserve antiquated rate choices, while the Settlement moves towards more modern rate choices. For these reasons, the 90-day trial approach should be approved.

- **The rate design for E-32 L, including the ratchet feature, is fair and provides appropriate cost-based incentives for energy storage.** The proposed rate E-32 L for large commercial and industrial customers, which retains its existing ratchet demand rate feature, is common in the utility industry and helps ensure that customers pay for the grid infrastructure costs necessary to serve them. It also provides incentives for energy storage and energy efficiency that better matches the customer's bill savings with the utility's cost savings, minimizing the shift of unrecovered grid costs to other customers. Furthermore, the ratchet is important to help focus technologies that reduce load in summer

months, when the load reduction is needed, and not over-reward load reduction in the winter when load reduction is generally not needed.

EFCA's claim that the ratchet will eliminate any first year savings from energy storage and will generally impede the adoption of energy storage and energy efficiency is unfounded. In fact, APS customers served under the rate have continued to implement energy efficiency investments, even with the ratchet feature.

EFCA's other rate design proposals are speculative, not supported by credible evidence and could result in unintended risks to customers. For these reasons, APS believes that EFCA's proposals should not be adopted.

III. RESIDENTIAL BASIC SERVICE CHARGES

Q. WHAT ARE BSCS NOW IN RELATION TO THE PROPOSED LEVELS?

A. Current basic service charges for residential rates are $8.67 per month for about 45% of our customers and $16.91 for the other 55%. The basic service charges under the Settlement range from $10, $13, $15, and $20 for the proposed new rate choices.

Q. WHAT IS SWEEP'S AND AARP'S CRITICISM OF THE SETTLEMENT BSCS?

A. SWEEP opposes the Settlement BSCs claiming that "The majority of APS residential customers would see significant increases in their BSCs."[1] AARP claims that the BSC proposal for R-Basic "would amount to an 87.5% increase from the $8.00 that most residential customers on a basic plan now pay...."[2] SWEEP further objects to the increases in BSCs for the R-Basic and R-Basic Large rates, which are $15 and $20 per month respectively. AARP takes no position on the R-XS or R-Basic Large rates.

[1] SWEEP – Direct Settlement Testimony of Jeff Schlegel, page 4, line 1.
[2] AARP – Direct Settlement Testimony of John B. Coffman, page 3, line 25-26.

Q. ARE SWEEP AND AARP ACCURATE?

A. No, quite the reverse. Under the Settlement, over half of APS's residential customers will see a significantly lower BSC and another 25% will see a very modest $1.33 per month increase in their BSC.

Q. HOW DO THE SETTLEMENT BSCS COMPARE WITH OTHER ARIZONA UTILITIES?

A. A comparison of the Settlement BSCs and recently approved BSCs for other Arizona utilities shows that the Settlement BSCs range from $10 to $20 with the majority (approximately 85%) of residential customers in the $10 to $15 category. Other utilities recently approved BSCs range from $10 to $15 and are therefore entirely consistent with this Settlement proposal as well.

Q. WHAT ABOUT SWEEP'S CONCERN OVER THE HIGHER BSC FOR THE R-BASIC LARGE RATE?

A. The BSC for rate R-Basic-L, which is $20 per month, is higher than the current BSCs; it is also higher than the Settlement BSCs for other residential rates. However, this rate is only available, on a volunteer basis, for larger customers with average monthly usage of 1,000 kWh or more. Furthermore, as shown in Table 1, this group of customers will have other rate options—options that will almost certainly result in lower bills and involve significantly lower BSCs.

Table 1 Basic Service Charges and Bills for R-Basic Large and Alternative Rates

Avg kWh	R-Basic L	TOU-E	R-2	R-3	Best Rate
BSC	20	13	13	13	
1,027	157.76	144.26	146.39	154.75	TOU-E
1,264	189.55	174.64	175.64	184.50	TOU-E
1,539	226.43	209.38	199.19	199.56	R-2
2,025	291.61	271.41	254.04	251.16	R-3
3,240	454.57	426.41	385.06	369.09	R-3

In addition, the higher BSC for this rate will encourage customers to move to a TOU energy rate or a TOU demand rate, a transition that is better for the customer, reduces system costs, and is an objective of the Settlement.

Q. WHAT BSC DOES SWEEP PROPOSE FOR RATE R-BASIC?

A. SWEEP recommends a BSC for rate R-Basic of $8 per month, rather than the Settlement amount of $15 per month.

Q. WHAT IS APS'S RESPONSE?

A. SWEEP's recommended BSC is a significant reduction from both the current BSCs and the new charges agreed to in the Settlement. Currently, customers that would qualify for the new rate R-Basic are paying a BSC of either $8.61 per month under rate E-12 or $16.91 per month under a current time-of-use or demand rate. SWEEP's proposed $8 BSC is, on average, substantially below the current charges.

Furthermore, SWEEP's proposed BSC does not recover the types of customer-related costs that are generally considered to be appropriate to recover in a BSC by a variety of constituents nationally with considerably different viewpoints on this issue. For example, SWEEP's proposed BSC would not even recover the monthly metering costs, let alone other generally accepted customer-related costs, such as billing and customer service.

Q. WILL SWEEP'S PROPOSED BSC REQUIRE AN INCREASE TO THE ENERGY CHARGES FOR RATE R-BASIC?

A. Yes. SWEEP's proposed $8 BSC for rate R-Basic will require the kWh energy charges to be increased by over 7%, which could adversely impact customers in that group.

Q. AARP CLAIMS THAT THE SETTLEMENT BSCS WILL RESULT IN CUSTOMERS HAVING LESS CONTROL OVER THEIR BILL. WHAT IS APS'S RESPONSE?

A. APS disagrees. The Settlement BSC structure will encourage customers to enroll in a TOU energy or TOU demand rate, which provides customers with additional ways to control their usage and save on their bill.

Moreover, while it is important for customer's to have control over their bill, this control should be over the cost components of the bill that actual vary with customer usage. It doesn't provide system savings or benefits to other customers, let alone promote efficiency, for a customer to "have control," i.e. be able to reduce, the portion of the bill that recovers the cost of the meter, for example, or other fixed costs that do not vary with a customer's monthly usage. Such reductions in the fixed-cost portions of the bill that are not accompanied by actual cost savings would shift the recovery of those costs to other customers.

Q. DO HIGHER BSCS FOR R-BASIC RESULT IN HIGHER CUSTOMER BILLS?

A. No. As shown below in Table 2, a typical R-Basic customer using 773 kWh per month would have an average monthly bill of $110.61 under Rate R-Basic, a bill of $111.56 under rate TOU-E, and higher bills under Rates R-2 and R-3. The comparative BSCs are $15 per month for R-Basic and $13 per month for the other rate choices. Therefore, the typical R-Basic customer will have a lower bill compared to the other rate choices even though the BSC is higher.

Table 2 Bill Comparison for Typical R-Basic Customer[3]

Avg kWh	Transition E-12	R-Basic	TOU-E	R-2	R-3	Best Rate
773	110.61	110.74	111.56	114.75	121.93	R-Basic

Q. WHAT DOES APS RECOMMEND CONCERNING RESIDENTIAL BSCS?

A. The Settlement BSCs were derived through compromise, are lower for the majority of customers and are designed to encourage customers to move to TOU rates. For these reasons APS recommends the Settlement BSCs should be approved.

[3] Bills exclude adjustors and taxes

IV. NEW ON-PEAK HOURS FOR TOU RATES

Q. WHAT DOES SWEEP CLAIM CONCERNING THE NEW ON-PEAK HOURS FOR RESIDENTIAL TOU RATES?

A. SWEEP opposes the new TOU on-peak hours, which are 3 p.m. to 8 p.m. weekdays, with 4 new exempt holidays, claiming that the new five-hour on-peak window is too long and "virtually mandates that the family will face high on-peak charges without any real flexibility to move some activities and energy use to off-peak periods."[4]

Q. PLEASE EXPLAIN WHY SWEEP'S TOU PERIOD WOULD BE INAPPROPRIATE.

A. First of all, the new on-peak TOU hours are significantly shorter than those in the two current residential TOU rates, which are 9 a.m. to 9 p.m. weekdays, with no exempt holidays, and 12 noon to 7 p.m. weekdays, with six exempt holidays. In other words, the proposed new 5-hour on-peak window is significantly shorter than the 12-hour and 7-hour current on-peak periods.

Q. DOES SWEEP PROVIDE ANY EVIDENCE TO SUPPORT THEIR CLAIMS?

A. No. SWEEP claims that the new hours will make it virtually impossible for customers to respond to the rate and shift usage to off-peak hours, compared to the current rates which actually have longer on-peak hours. However, they offer no supporting evidence and their reasoning falls short.

Moreover, SWEEP appears to ignore the purpose for designating on-peak hours and the importance of accurately aligning on-peak hours with the system peak.

Q. WHAT IS THE PURPOSE OF A TOU RATE?

A. A TOU rate is designed to provide a higher price signal to customers when loads and costs are the higher and a lower price when loads and costs are lower. The objective is to incent customers to shift usage to off-peak hours and thereby reduce peak load and costs for the benefit of all customers.

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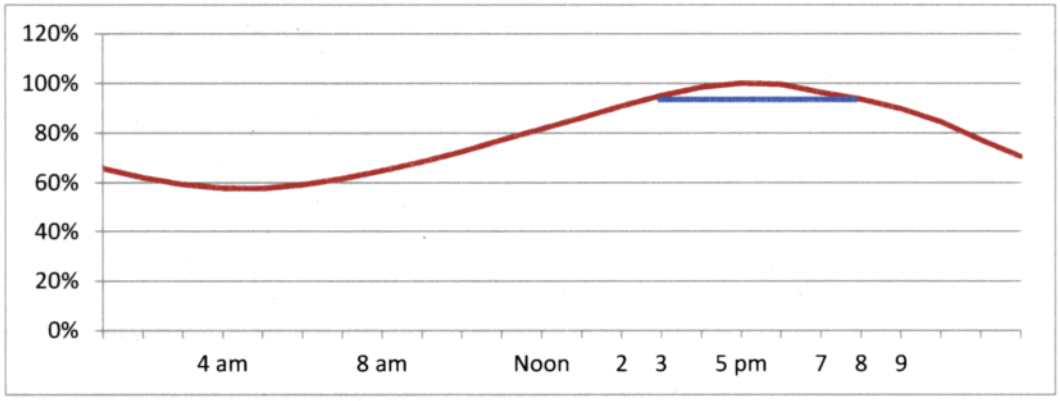
[4] SWEEP Direct Settlement Testimony of Jeff Schlegel, page 9, lines 34-36.

Q. WHEN DO APS SYSTEM PEAK HOURS OCCUR?

A. APS has a broad peak as high temperatures in summer months continue on late into the evening. The high peak hours occur in the mid-afternoon into the mid evening, typically from 3 p.m. to 9 p.m. at night. As shown in Figure 1, loads in these hours are typically within 10% of the single peak hour; from 3-8 p.m. loads are within 5% of the peak hour; and within 2% for 4-7 p.m. The Peak also spans quite a few days in the core summer months of June through September.

Figure 1 APS Summer System Sumer Peak Hours[5]



Q. HAVE THE HIGH SYSTEM PEAK HOURS CHANGED OVER TIME?

A. Yes. The high system peak hours and hours of critical generation resource needs have moved later in the day, towards the mid evening, over the last five years. The early afternoon hours, e.g. 1 p.m. and 2 p.m., have become less critical, and the mid-evening hours, e.g. 7 p.m. and 8 p.m. have become more critical. Furthermore, APS expects this

[5] Test Year 2015 system load, top 80 hours, June through September.

trend to continue with 7 p.m. and 8 p.m. becoming even more important on-peak hours in the future.

Q. DO THE SETTLEMENT ON-PEAK HOURS ANTICIPATE THIS ONGOING CHANGE?

A. Yes. The Settlement on-peak hours support both the current load patterns and the anticipated future trends. This is important because it will allow the on-peak billing hours to remain stable for a number of years and not be adjusted again, for example, in the next rate review.

Q. DO APS'S CURRENT RESIDENTIAL TOU HOURS COVER THE PERIOD WITHIN 10% OF SYSTEM PEAK?

A. The current series-1 TOU rates with the 9 a.m. to 9 p.m. on-peak hours covers this peak load period, but is longer than necessary on the front end. In addition, this rate has been frozen to new customers since January 2010. The current series-2 TOU rates with the 12 noon to 7 p.m. on-peak period does not cover the period within 10% of system peak load hours because it drops off at 7 p.m. when system loads and costs are still extremely high.

Q. WHY IS THE SETTLEMENT ON-PEAK PERIOD APPROPRIATE?

A. The Settlement on-peak hours of 3 p.m. to 8 p.m. is appropriate because it balances the cost basis for the TOU rate, which would warrant the on-peak period to be 3 p.m. to 9 p.m., with customer considerations, which shortens the on-peak period to 5 hours instead of 7. This balanced on-peak period still covers the high load hours which are within 5% of system peak, but allows customers a better opportunity to shift loads to off-peak hours and save on their bill.

Q. WHAT DOES SWEEP RECOMMEND?

A. SWEEP recommends that the new TOU hours for residential rates should be 4 p.m. to 7 p.m., which is 3 hours, rather than the 5 hours recommended by the Settlement.

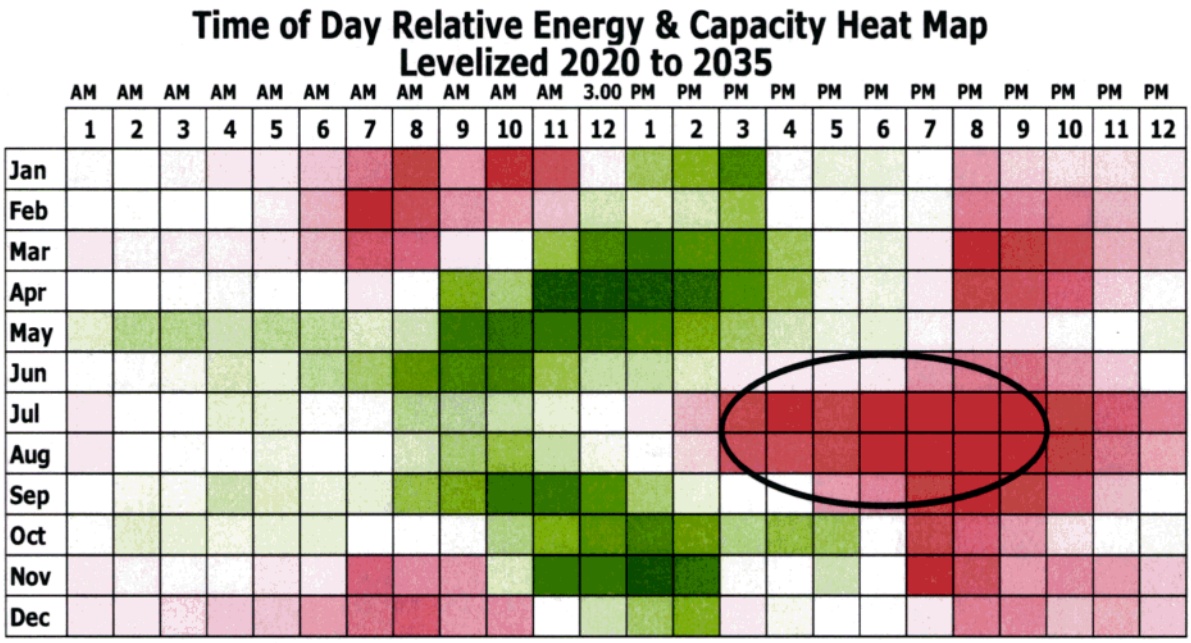
Q. DOES SWEEP OFFER ANY EVIDENCE TO SUPPORT THIS RECOMMENDATION?

A. No. SWEEP does not offer any evidence to adopt this recommendation. SWEEP's argument is that TOU rates would be more customer friendly if the on-peak hours did not occur when people were home using a lot of electricity. And while the argument might be appealing from an individual customer perspective, the objective of a TOU rate is to send appropriate price signals for conservation during times of high demand. As one might expect, peak load tends to occur when some people are at home using electricity. But, to be effective, on-peak periods for rates must reflect actual conditions, not ignore those conditions.

The record in this proceeding actually supports a 3 p.m. to 9 p.m. on-peak period as further demonstrated in the Figure 2 below, which shows high system load hours in red and relatively lower load hours in green. But considering customer's desires for shorter periods, APS initially proposed and continues to support the settled position of 3 p.m. to 8 p.m. on-peak period. SWEEP states that with the shorter time period "more customers would be able to work with and manage their energy usage during the peak periods – thereby resulting in less peak demand..."[6] SWEEP mistakenly seems to believe that changing the peak hours of the rate would somehow change when the peak period occurs. The shorter time period proposed by SWEEP would reward customers for shifting load from one peak hour to another. Doing so might actually increase the system peak, which would increase costs to customers.

[6] SWEEP Direct Testimony of Jeff Schlegel Page 10, lines 2-5.

Figure 2 APS System Peak Hours



Q. WHAT DOES APS RECOMMEND CONCERNING THE TOU ON-PEAK HOURS?

A. As stated, APS recommends that the Settlement on-peak hours should be approved. APS further recommends that SWEEP's proposal should not be adopted because their proposed on-peak hours do not correspond with APSs hours of high system peak and costs.

V. RESIDENTIAL RATE R-BASIC

Q. PLEASE EXPLAIN THE BENEFITS OF THE 90-DAY TRIAL PERIOD IN CONNECTION WITH RATE R-BASIC.

A. The Settlement is intended to make progress in modernizing rate design by moving all but the smallest customers away from flat two-part rates to TOU energy or TOU demand rates as much as possible. These advanced rates provide a better matching of rates with costs of service and allow customers more opportunities to save on their bill -

savings that also result in lower system peaks and costs. The issue is how to achieve this while preserving the R-Basic rate option for the present.

Q. HOW DID THE SETTLEMENT RESOLVE THESE ISSUES?

A. The negotiated solution is to have the R-Basic generally available to qualifying customers until May 2018. After that time, the rate would be available to additional customers after they had tried one of the other TOU rate choices for at least 90 days.

Under this compromise, the R-Basic rate would continue to be available as a rate option after May 2018, but the objective of moving customers to a TOU rate would be supported by a 90-day trial period.

Q. WHAT DO SWEEP AND AARP PROPOSE FOR THE RESIDENTIAL RATE R-BASIC?

A. SWEEP and AARP oppose the 90-day trial period because they claim it limits customer choice.

Q. WHAT IS APS'S RESPONSE?

A. Questions of rate options are driven by several policy considerations, including customer choice and the need to modernize rates. The goal should be to balance these policy considerations. The Settlement Agreement does just that by permitting customers to take service under R-Basic, but exposing them to more modern rate options. Customer choice is important and it has been preserved in this settlement. This settlement balances the desire to keep the basic rates option available but takes a significant step forward in modernizing rates. APS has greater customer interest and experience in time variant rates than any utility in the country and the Settlement takes another significant step towards modernizing rates.

Settling Parties agreed that it is important to move away from the old rate choices, but in a very measured way. The phase-in approach, with the transition period and 90-day trial period, was a compromise solution to this issue.

Moreover, more modern rates provide more meaningful control over customers' electricity usage by permitting them to modify their behavior and save money. This option to control one's usage reflects and satisfies the same rationale and policy objective driving the criticism of the 90-day trial period.

Q. DOES THIS PLAN LIMIT THE CHOICES OF LOW USAGE CUSTOMERS AS CLAIMED BY AARP?

A. No. Under the Settlement, low-use customers with average monthly usage of 600 kWh or less will continue to be offered a basic rate (two-part flat rate) option past May, 2018 without the 90-day trial period. The proposal for Rate R-Basic will only affect customers with average usage higher than 600 kWh per month.

Q. ARE OPT-OUT RATES BEING CONSIDERED AND IMPLEMENTED IN OTHER STATES?

A. Yes. The opt-out approach to phasing in modern rate designs, which is a more general, open-ended version of the 90-day trial provision adopted in the Settlement, is widely discussed in the utility industry and is beginning to be selectively used in some jurisdictions. While APS has not conducted an exhaustive survey, a couple of recent examples are the opt-out peak-time rebate rate program for all residential customers served by Constellation Energy[7] and the planned move to opt-out TOU rates for residential customers in California in the near future.[8]

Q. WHAT DOES APS RECOMMEND FOR THIS ISSUE?

A. APS believes that the 90-day trial period represents a balanced, compromise position which phases-in the modern rate choices while preserving the option for customers to take service under multiple rates. For these reasons, the Settlement recommendation for rate R-Basic should be approved.

[7] Baltimore Gas and Electric service territory.
[8] *See* CPUC Decision D.15-07-001.

VI. RATE E-32 L RATCHET PROVISION

Q. PLEASE DESCRIBE RATE E-32-L.

A. Rate E-32 L is an existing three-part demand rate for large commercial and industrial customers. It includes a basic service charge, an energy charge and a demand charge. The monthly demand charge is based on the monthly metered kW demand or 80% of the peak metered demand during summer months, whichever is greater. The latter is commonly referred to as a ratchet provision.

Q. WHAT ISSUES DOES EFCA HAVE CONCERNING THE RATCHET PROVISION IN THIS RATE?

A. EFCA would like the ratchet provision exempted for customers that adopt energy storage. EFCA witness Garratt claims that the ratchet: is inconsistent with cost based ratemaking; eliminates storage as a viable option for customers; undermines incentives for energy efficiency; and is essentially the same as a fixed monthly BSC.[9] He also suggests that there is a national trend for eliminating demand ratchets.

Q. DOES EFCA PROVIDE ANY EVIDENCE TO SUPPORT THESE CLAIMS?

A. No. EFCA's claims are unsubstantiated opinions and unsupported by any evidence.

Q. PLEASE EXPLAIN.

A. As discussed in my Direct Settlement Testimony, the demand ratchet does not eliminate the benefits of adopting energy storage, or energy efficiency for that matter. Rather, it helps to focus these technologies on reducing load during summer months, when the reduction is most needed, and does not over-reward customers for reducing load during winter months, when the load reduction is largely not needed.

Furthermore, in my Direct Settlement Testimony, I refute EFCA's exaggerated claim that all first-year benefits of energy storage would be eliminated with the ratchet. I demonstrate with a simple billing example that this issue could be predominately

[9] EFCA – Direct Settlement Testimony of Mark Garrett, pages 4, 6, and 8.

addressed with the timing of the installation of storage projects. That is, customers could realize substantial first-year savings if they installed the unit prior to the summer billing period.

Q. EFCA SEEMS TO BELIEVE THAT THE GOAL IS TO PROVIDE AS HIGH OF AN INCENTIVE AS POSSIBLE FOR STORAGE AND ENERGY EFFICIENCY. DO YOU AGREE?

A. No. The objective should be to "right-size", rather than maximize, the rate incentives for energy storage and energy efficiency. In other words, the customer's bill savings from adopting energy storage or energy efficiency should be as consistent as possible with the savings in the utility's costs necessary to serve them. If the bill savings equals the cost savings, then there are no unfunded grid costs that are shifted to other customers for recovery. APS believes that preventing this cost shift is fair and beneficial to all customers. If, as EFCA seems to suggest, the rate is designed to maximize bill savings for an individual customer irrespective of the actual reduction in costs to serve that customer, the result will be another "net metering type" problem with significant cost shifting to non-storage customers.

Q. WHAT IF THE COMMISSION WANTS TO FURTHER INCENT ENERGY STORAGE BEYOND THE BILL SAVINGS?

A. The best way to ensure the long term health of distributed technology is to have those technologies compete on the basis of actual cost savings. Doing so insulates them from relying on artificial subsidies that can be taken away. If incentives are still needed, the best course is to do so with broad public policy decisions, such as tax incentives. The worst way to incent storage is to bury the incentive in non-cost-based rate design, which only results in open-ended and unmonitored subsidies.

Q. HAS THE DEMAND RATCHET ELIMINATED THE ADOPTION OF ENERGY EFFICIENCY FOR LARGE CUSTOMERS AS CLAIMED BY EFCA?

A. No. This exaggerated claim is simply unfounded. APS large customers continue to invest in energy efficiency under the demand ratchet. Recent customer installations of energy efficiency technologies, most of which reduce the summer air-conditioning load,

or involve efficient motors and processes that reduce the summer peak demonstrate the current E-32 L rate design, with the ratchet provision, can appropriately incent energy efficiency. Furthermore, because the current rate design is cost based, it aligns energy efficiency cost savings with system costs, which mitigates the cost shift to other customers.

Q. CAN YOU GIVE SOME EXAMPLES?

A. Yes. In 2016, the Solutions for Business program provided approximately 226 GWh of annual energy savings. The contribution from customers served under the E-32 L rate was 59 GWh or roughly 26% of the total savings from commercial and industrial customers. By comparison, the total energy sales during the Test Year for rate E-32 L were 25% of the total sales for the commercial and industrial class. This means that the E-32 L customers participated in energy efficiency in the roughly the same proportion, if not slightly higher, as other customers in this class.

Examples of energy efficiency investments for E-32 L customers include: demand control ventilation, refrigeration and evaporative condensers in grocery stores; HVAC, guest room fan motors and lighting retrofits in a resort; HVAC controls and lighting retrofits for movie theatres; variable frequency drives and energy efficient new construction design for a college; and energy efficient switching modules for a telecommunications company. These examples show, along with the overall program results, that customers continue to invest in energy efficiency technology under the E-32 L rate with the ratchet provision.

Q. ARE DEMAND RATCHETS COST-BASED?

A. Yes. I provide a discussion of the purpose and cost basis for demand ratchets in my Direct Settlement Testimony, and explain that while most grid costs are driven by summer peak demands, APS recovers these costs through monthly demand charges throughout the year. The ratchet helps to ensure that the grid infrastructure costs are recovered from the customers that cause them more evenly over the year. Over the entire

year, the customer will fairly contribute to grid costs, even if their load drops off significantly during non-summer months.

Q. IS EFCA'S ALTERNATIVE PROPOSAL TO ONLY APPLY DEMAND CHARGES TO SUMMER MONTHS FEASIBLE?

A. No. While this approach would conceivably eliminate the need for a demand ratchet, it could also likely result in significant cash flow issues for the customers through dramatically increased summer bills, and undermine the rate design goals of customer bill and utility revenue stability.

Q. IS THERE A NATIONAL TREND TOWARDS ELIMINATING DEMAND RATCHETS AS INTIMATED BY EFCA?

A. No. In fact, the trend is quite the reverse. Demand ratchets for large commercial and industrial rates are widely used in the utility industry, and widely considered to be an important safeguard in ensuring that large customers pay for the grid infrastructure costs necessary to serve them and do not shift these costs to other customers. EFCA's citation of one state—Massachusetts—is not compelling. Massachusetts is a direct access state with electric rates significantly above the national average; it is probably not an appropriate example for Arizona to copy.

Q. WHAT ABOUT THE RECENT RATCHET ISSUES FOR UNSE AND TEP DISCUSSED BY EFCA?

A. APS notes that the recent ratchet provisions for UNSE and TEP are for future consideration and nothing has been approved by the Commission at this point. APS is concerned, however, that the provisions cited by EFCA appeared have taken place with little discussion and without the potential merits and risks to customers fully vetted.

Q. DOES EFCA RECOMMEND OTHER CHANGES TO RATE E-32L?

A. Yes. EFCA basically recommends that the entire rate structure for Rate E-32L and E-32 TOU L be revised, including the tiered demand charge structure, the on-peak and off-

peak demand charges, the metering basis for computing the monthly demand, and the necessary associated revisions to the energy charges and the monthly BSC.[10]

Q. WHAT IS APS'S RESPONSE TO EFCA'S RATE DESIGN PROPOSALS FOR RATES E-32 L AND E-32 TOU L?

A. Their proposals do not have merit and are unsupported by evidence. The two-tiered demand charge for rate E-32 L is designed to recover two different types of grid costs. The first tier recovers distribution grid costs that are closer in nature to a customer-related cost and could alternatively be recovered through a higher basic service charge, while the second tier recovers distribution grid costs that are more consistently driven by the customer's kW demand. Therefore, contrary to EFCA's claims, the tiered demand structure has a valid cost basis.

Likewise, the off-peak kW charge for rate E-32 TOU L is consistent with cost of service and is important for ensuring that each customer pays their fair share of grid costs. The off-peak demand charge appropriately recognizes that while most grid costs are driven by on-peak kW load, some grid costs can be driven by the customer's maximum load, whether it occurs during on-peak hours or off-peak hours. For example, a large customer that shifts their entire load to the off-peak period will still incur some grid costs – especially the delivery-related costs that are closer to the customer's site.

Q. ARE THEIR ALTERNATIVES TO EFCA'S PROPOSALS?

A. Yes. For example, as stated, the tiered kW charge for rate E-32 L could be replaced with a single (non-tiered) demand charge and a higher basic service charge that recovers all, or part of, the costs associated with the first-tier kW charge.

In addition, the off-peak kW charge for rate E-32 TOU L could be replaced with two demand charges – an on-peak demand charge and an untimed demand charge, which is based on the customer's maximum load, whenever it occurs.

[10] EFCA – Direct Settlement Testimony of Mark Garrett, pages 11-15.

Q. DOES APS RECOMMEND THESE ALTERNATIVES?

A. No. These potential alternatives are different ways of addressing the same cost drivers as the current rate E-32 L and E-32 TOU L rate designs. They are not universally better or worse than the current designs—they have advantages and disadvantages. They also potentially have unintended customer consequences. For these reasons, and because the current designs and charges were negotiated by a variety of parties to the Settlement, APS does not see a compelling reason to change the current design of these rates.

Q. PLEASE SUMMARIZE YOUR REBUTTAL OF EFCA'S POSITION ON RATE E-32 L?

A. EFCA's claims that the Settlement rate design for rate E-32 L, with the ratchet provision, is not cost based and will significantly impede that implementation of energy storage and energy efficiency is highly exaggerated, unsupported by evidence, and unfounded by actual experience. The key points are:

1. The ratchet feature is an important cost-based rate design element which helps to "right-size" the bill savings for energy storage and energy efficiency and ensures that such investments do not result in unfunded grid costs that are shifted to other customers.

2. The ratchet feature and overall rate design provides ample opportunity for bill savings from energy storage, even in the first year of installation.

3. Contrary to EFCA's claim, the ratchet has not impeded the adoption of energy efficiency investments by APS's E-32 L customers.

4. Contrary to EFCA's claim, there is no national trend of eliminating ratchets in the rates for large commercial and industrial customers. In fact, demand ratchets continue to be an important part of cost-based rates for many utilities.

5. EFCA's other recommendations concerning the E-32 L rate design, beyond the ratchet discussion, do not have merit.

In addition, if, as EFCA seems to suggest, the E-32 L rate is redesigned to maximize bill savings from storage for an individual customer - irrespective of the actual reduction in costs to serve that customer, the result will be another "net metering type" problem with significant cost shifting to non-storage customers.

Q. WHAT DOES APS RECOMMEND CONCERNING EFCA'S PROPOSALS?

A. APS recommends that EFCA's proposal to eliminate the ratchet provision for Rate E-32 L and E-32 TOU-L for storage customers not be adopted. Rather, the Settlement rate design for these two rates should be approved as proposed for all customers, including those who install energy storage.

In addition, EFCA's other rate design proposals should also not be adopted because they are speculative and unsupported, do not reflect cost of service, could result in unintended negative impacts on customers.

VII. CONCLUSION

Q. PLEASE SUMMARIZE YOUR RECOMMENDATIONS.

A. APS recommends that the Commission approve the Settlement, the proposed rate design for rate E-32 L, which maintains the current ratchet feature.

Q. DOES THIS CONCLUDE YOUR SETTLEMENT REBUTTAL TESTIMONY?

A. Yes.

Exhibit 4

SETTLEMENT REBUTTAL TESTIMONY OF
SCOTT B. BORDENKIRCHER
On Behalf of Arizona Public Service Company
Docket Nos. E-01345A-16-0036 & E-01345A-16-0123

April 17, 2017

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SETTLEMENT REBUTTAL TESTIMONY OF SCOTT B. BORDENKIRCHER
ON BEHALF OF ARIZONA PUBLIC SERVICE COMPANY
(Docket Nos. E-01345A-16-0036 & E-01345A-16-0123)

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME, ADDRESS, AND OCCUPATION.

A. My name is Scott B. Bordenkircher. I am the Director of Transmission and Distribution Technology Innovation and Integration at Arizona Public Service Company (APS or Company). My business address is 400 N. 5th Street, Phoenix, Arizona 85004.

Q. DID YOU PREVIOUSLY FILE TESTIMONY IN THIS MATTER?

A. Yes. I presented direct testimony in this case on June 1, 2016.

Q. WHAT IS THE PURPOSE OF YOUR SETTLEMENT REBUTTAL TESTIMONY IN THIS PROCEEDING?

A. My testimony will explain why APS's Advanced Metering Infrastructure (AMI), described in my direct testimony, is important and beneficial to both the Company and its customers, and is an entirely appropriate technology for APS to have implemented. I will respond to many of Intervenor Woodward's concerns regarding AMI meters, including his assertions that AMI meters violate customer privacy, are vulnerable to hacking, and cause fires. I will also briefly address Mr. Woodward's statements regarding health concerns and the suggestion of Witness Anderson that AMI meters affect power quality. Finally, I will provide comments on a few of the various studies and utility proceedings cited by Mr. Woodward.

II. SUMMARY

Q. PLEASE SUMMARIZE YOUR TESTIMONY.

A. My testimony focuses on explaining the benefits of APS's AMI system and the importance of AMI metering for grid modernization. AMI technology benefits APS customers in many ways and also provides APS's system operators critical visibility into the day-to-day operation of the grid. This supports the Company in its efforts to maintain the overall health and reliability of the grid.

Additionally, my testimony discusses many of the concerns raised about AMI meters. However, silence on any particular point is not meant to indicate acceptance. My testimony addresses Intervenor Woodward's concerns about privacy and cybersecurity. Protecting customer information is a critical priority for APS. To accomplish that protection, APS complies with all Commission regulations, approved rate and service schedules, state statutes, and federal regulations regarding privacy and security of customer information.

I also address allegations of fire risk and damage to or interference with household appliances caused by AMI meters. APS has no knowledge of increased risk of fires or damage to household appliances caused by AMI meters. APS is aware of less than five instances where AMI meters have interfered with other technologically-advanced transmitting equipment and in all of those instances, APS has worked with the customer to resolve the issue.

I discuss the health concerns raised by Mr. Woodward and his two witnesses, Dr. Milham and Mr. Anderson. The radio frequency (RF) transmissions of the type utilized by AMI are regulated by the Federal Communications Commission (FCC). The Arizona Department of Health Services conducted a study on the safety of APS's AMI meters and the resulting report published in November 2014 confirmed that the meters tested were operating within the FCC's standards.

My testimony discusses the accuracy of AMI meters and addresses Mr. Woodward's concerns that AMI meters are less accurate than analog meters. To the contrary, due to there being no moving parts in an AMI meter, it maintains greater long-term accuracy than analog meters, which wear and degrade over time. Both of APS's AMI vendors test and certify for accuracy 100% of the meters they produce and send to us.

Lastly, my testimony addresses two specific documents cited by Mr. Woodward: the comments of Northeast Utilities (Woodward Exhibit B) and a 2010 White Paper from the Electric Power Research Institute (EPRI) (Woodward Exhibit V).

III. THE BENEFITS OF ADVANCED METERING INFRASTRUCTURE

Q. PLEASE GIVE A BRIEF OVERVIEW OF THE COMPANY'S AMI SYSTEM.

A. As I noted in my direct testimony, AMI is an integrated metering technology that provides APS with the ability to remotely perform many meter-related functions that the Company had previously performed manually. AMI technology is broader than just the measurement of customer electricity usage through a meter; the AMI system includes communication networks and data management systems that together allow APS to increase overall efficiency and improve customer service.

Q. DO CUSTOMERS BENEFIT FROM AMI?

Absolutely. AMI technology benefits APS customers in many ways. AMI metering helps customers manage energy usage and reduce monthly bills by providing daily usage data. This data can be viewed on the Company's website aps.com, allowing customers to track and understand when and how they use electricity. Additionally, because this data is available, customers may receive individualized alerts regarding their energy usage and bill amounts, which will provide even more control over their energy use. Customers can also minimize delays when requesting connect or disconnect service because physical visits are not required.

AMI also provides benefits that may not be immediately obvious to customers. For example, AMI metering lowers the Company's operating costs because monthly meter reads, customer move-in/move-outs, and meter rate changes (customers changing from one rate to another) can now be conducted remotely. These meters also provide the Company with the ability to measure power quality, ensuring that electricity delivered to customers is within the correct voltage range. AMI meters also transmit a signal when

meter tampering is attempted, allowing APS to correct the situation quickly to reduce energy theft and fraud.

Q. IS AMI AN IMPORTANT PART OF THE EVOLUTION OF THE GRID?

A. Without a doubt. The modernization of the electric grid starts with more timely and accurate information about its operation. In order for APS, and in fact the whole industry, to be positioned to accept further expansion of renewable resources and other customer-sited choices, the utility must accurately understand the effects of those systems on the grid they are tied to. AMI provides system operators critical visibility into the day-to-day operation of the grid including system loading and solar production, which allows the Company to gain a better awareness of the overall health and reliability of the grid. It is one of the foundational platforms upon which the future grid will be based.

IV. ADVANCED METERING INFRASTRUCTURE IS ACCURATE AND SECURE

Q. HAVE YOU REVIEWED INTERVENOR WARREN WOODWARD'S DIRECT TESTIMONY IN OPPOSITION TO THE SETTLEMENT AGREEMENT?

A. Yes. My testimony focuses on certain arguments Mr. Woodward makes, including privacy, cybersecurity, fires, health, and the accuracy of AMI. Barbara Lockwood will also address the settlement process and Mr. Woodward's allegation of discrimination in the Settlement Agreement. Silence on any particular point does not indicate acceptance.

Q. DO AMI METERS POSE INCREASED PRIVACY OR CYBERSECURITY CONCERNS?

APS cannot control whether and how third-party bad actors attempt to engage in illegal activity, regardless of which technologies it employs. APS has implemented AMI to improve grid operation for its customers. What APS can do, indeed what any utility can and should do, is rigorously adopt best practices to protect the privacy, security, and safety of customers and their data.

Protecting customer information is a critical priority for APS. To accomplish that protection, APS complies with all Commission regulations, approved rate and service

schedules, state statutes, and federal regulations regarding privacy and security of customer information. Additionally, APS follows up with regular reminders and training for APS employees, including annual mandatory training on the Company's code of ethics, which specifically identifies customer information as confidential and restricts the release or disclosure of this information to outside parties.

APS has been maintaining the cyber security of its critical systems and its customer's privacy for decades. APS takes the security and privacy of its customers extremely seriously. APS has deep and extensive experience in this area and carefully assesses and mitigates cybersecurity risks, including those brought about by the addition of new technology. APS's cyber security practices are built around a defense-in-depth model, which is considered best practice in the industry. In addition, APS's practices are constantly reviewed both internally and by third parties, and are updated as necessary to protect against emerging threats.

Q. DO YOU HAVE ANY KNOWLEDGE OF AN INCREASED AMOUNT OF FIRES DUE TO THE USE OF AMI METERS?

A. No. As mentioned in response to a question in the ACC's 2014 investigation, there have been some fires within the APS service territory that were initially alleged to have been caused by Elster meters. However, in all of these instances, a root cause external to the meter itself, such as broken or loose meter clips or defective wiring at the location, was determined to be the cause of the fire.

Q. DO AMI METERS DAMAGE OR INTERFERE WITH HOUSEHOLD APPLIANCES AND ELECTRONICS?

A. No, APS has no evidence of AMI meters damaging other customer appliances or electronics. APS is aware of less than five occurrences where AMI has interfered with other technologically-advanced transmitting equipment. This is similar to the interference caused in some cases by the first generation of LED light bulbs. In all cases regarding AMI where this has occurred, APS has worked with the customer to resolve the issue to the customers' satisfaction.

Q. DO YOU HAVE A RESPONSE TO MR. WOODWARD'S ALLEGATIONS THAT APS'S USE OF AMI METERS RESULTS IN TRESPASS AND THEFT?

A. Yes, although I am not a lawyer and do not provide a legal opinion, I believe Mr. Woodward's allegations stem from his flawed argument that APS's AMI meters are not meters. Per Service Schedule 1 (the Commission-approved terms and conditions of service which are considered a part of all rate schedules, except where specifically excluded or changed by a written agreement), the definition of a meter is "the instrument used for measuring and indicating or recording the flow of electricity that has passed through it".[1] This is precisely the key function of AMI meters. In fact, APS has committed neither theft nor trespass because it has both a right and an obligation to install a meter at every customer's point of service. Service Schedule 1 further mandates that "all energy sold to the Customer will be measured by commercially acceptable measuring devices." Not only do APS's AMI meters meet this definition and purpose, they are fully compliant with all regulations and laws that dictate APS's use.

Q. DOES APS HAVE ANY REASON TO BELIEVE THAT AMI METERS POSE A HEALTH RISK TO ITS CUSTOMERS AS DESCRIBED BY DR. SAM MILHAM?

A. No. The Arizona Corporation Commission spent three years performing an inquiry in Docket No. E-00000C-11-0328 regarding the health, safety and functionality of advanced meters.

As part of that inquiry, the ACC requested that the Arizona Department of Health Services (ADHS) conduct a study on the safety of AMI meters. The resulting report published in November 2014[2] confirmed that the meters tested were operating within Federal Communications Commission's (FCC) standards. The ADHS report is attached as Attachment SBB-1SR. RF transmissions of the type utilized by AMI are regulated by the FCC, and APS's AMI meters fully comply with all FCC regulations.

[1] A.A.C. R14-2-201(25)
[2] Docket No. E-00000C-11-0328.

Furthermore, the use of AMI is not a technology unique to APS, but in fact as of December 2015, there were more than 64 million AMI meter installations in the United States alone.

Q. DO AMI METERS ACCURATELY MEASURE CONSUMPTION AND SOLAR OUTPUT?

A. Yes. All meters used by APS are required to meet ANSI C12.20 standards Accuracy Class 0.2%. In fact, due to there being no moving parts in an AMI meter, it maintains greater long-term accuracy than analog meters, which wear and degrade over time. Both of APS's AMI vendors test and certify for accuracy 100% of the meters they produce and send to us. In addition, APS also tests a random sample of all meters it receives.

Q. WHY IS IT REASONABLE THAT UNDER THE SETTLEMENT AGREEMENT DISTRIBUTED GENERATION (DG) CUSTOMERS ARE NOT ELIGIBLE FOR NON-STANDARD METERING?

A. Under the Agreement, DG customers are not eligible for non-standard metering for several important reasons. First and foremost, APS needs timely metered data from DG customers to support critical grid planning and operations, something that non-standard metering cannot support. It is critical to APS's grid reliability and load forecasting accuracy that APS have current production data from all rooftop solar systems. It would not be timely or practical to collect this data manually, and significant lags in obtaining this information could complicate distribution system configuration and capacity planning, potentially resulting in outages or equipment overloads.

Furthermore, APS believes it is important to provide timely energy usage and demand information to customers, which is made available with AMI metering. This is especially important for customers that adopt new distributed technologies, like rooftop solar, in order to obtain the best value for the grid and the best potential bill savings for the customer. It is vital to have a grid that can integrate all home energy technologies, such as distributed generation, energy storage, and demand response, as valuable resources for the future. AMI metering is fundamental to enabling this customer choice

while mitigating impacts to reliability. Lastly, APS believes this exclusion is consistent with SRP's non-standard metering program and those of other Arizona electric utilities.

Q. ARE THERE METERS THAT ARE NO LONGER BEING MANUFACTURED? WHAT DOES THIS MEAN FOR SELECTING METERS?

A. Yes. Analog meters can no longer be purchased from APS's meter vendors because they are no longer being manufactured. Used analog meters can still be found on the secondary market, but these are typically refurbished and may not meet APS's quality controls for reliability and customer safety. This lack of future availability further demonstrates the reasonableness of moving away from analog meters.

Q. DO YOU HAVE ANY COMMENTS ON METER LIFE?

A. Yes. APS had proposed a 20-year service life in its depreciation rate study, which was 6 years shorter than what was previously approved in the last rate case. Although APS would certainly have accepted a shorter meter life, a 20-year service life was adopted by the Settling Parties as a reasonable number for depreciating AMI and non-AMI meters.

V. ADVANCED METERS DO NOT AFFECT POWER QUALITY

Q. DIRECT TESTIMONY BY MR. ERIK ANDERSON SUGGESTED THAT SMART METERS HAVE A DETRIMENTAL EFFECT ON THE QUALITY OF THE INCOMING ELECTRICAL POWER VOLTAGE WAVEFORM. WHAT HAS BEEN APS'S EXPERIENCE WITH THE EFFECTS OF SMART METERS ON THE POWER QUALITY OF ELECTRICITY SUPPLIED TO YOUR CUSTOMERS?

A. APS has not seen or experienced any negative impacts on the power supplied to customers due to the use of AMI meters. In addition, although Mr. Anderson focuses on a particular meter, the manufacturer that builds that meter has confirmed that they also have not seen any impact to power quality due to the meters. If the implication made by Mr. Anderson was true—that the particular AMI meter has a significant impact on the quality of the power provided to the customer—we would expect to see widespread effects not only in our system, but throughout the entire utility industry. We are not, however, suggesting that Mr. Anderson's opinion does not reflect actual events.

Q. HOW DO YOU RESPOND TO MR. ANDERSON'S ALLEGATION THAT "THE AMOUNT OF NOISE, WITH THE SMART METER ATTACHED TO THE

CIRCUIT WAS APPROXIMATELY TWICE AS LARGE THAN WITHOUT THE SMART METER"?

A. The electrical noise measurements supplied by Mr. Anderson are very small. The highest noise magnitude he has identified is 0.085 Volts, but this represents only 0.05 percent of the normal 60 Hertz voltage signal. This extremely small quantity of noise is insignificant and does not cause any problems for the system or customers. Additionally, APS conducted its own measurement, but was unable to duplicate the magnitude of Mr. Anderson's measurements. APS tests showed no measurable impact on the normal 60 Hz waveform.

VI. COMMENTS ON DOCUMENTS CITED BY INTERVENOR WOODWARD

Q. DID YOU REVIEW THE STUDIES AND OTHER DOCUMENTS CITED BY MR. WOODWARD IN HIS DIRECT SETTLEMENT TESTIMONY?

A. Yes, I did. Mr. Woodward provides a number of citations to studies, filings, comments and other documents to support his belief that AMI technology should not be adopted. I will address two of these documents here: the comments of Northeast Utilities (Woodward Exhibit B) and a 2010 White Paper from the Electric Power Research Institute (EPRI) (Woodward Exhibit V).

Q. PLEASE ADDRESS THE COMMENTS OF NORTHEAST UTILITIES.

A. Northeast Utilities (NU) filed comments (dated January 17, 2014) in the Massachusetts Department of Public Utilities (MDPU) proceeding in which the MDPU was investigating modernization of the state's grid. NU's comments are a reaction to the MDPU Staff's recommendation that mandated implementation of AMI was necessary to achieve the goals set forth for grid modernization.

Mr. Woodward extensively quotes these comments in his testimony; however, he fails to recognize NU's situational differences from many others in the utility industry, including APS's. One key reason for NU's negative AMI stance in their comments is due to the fact that the entity had already implemented Automated Meter Reading (AMR) technology in their service territories at a significant cost. Because AMR

provides many of the same benefits of AMI, NU objected to the idea of forced replacement of one recently installed metering system with another that would provide only incremental benefits.[3] In addition, NU's service territory is decidedly different from the desert southwest served by APS. This environment includes some specific, and important, differences; namely much higher levels of customer-sited PV adoption, the transient nature of Arizona's winter visitors, and APS's load factor. All three of these differences had a part in APS's decision to deploy AMI in order to increase reliability, facilitate customer choice and save considerable money for its ratepayers by automating both reading meters, as well as allowing remote rate plan updates and turn-ons and shut-offs.

NU's response was an arguably reasonable reaction to the MDPU's recommendation of significant additional investment that they viewed as unnecessary given their particular service environment and existing investment in AMR. It in no way invalidates the benefits or appropriateness of the adoption of AMI by APS.

Q. PLEASE COMMENT ON THE EPRI STUDY CITED BY MR. WOODWARD.

A. The EPRI white paper, titled "Accuracy of Digital Electricity Meters," appears to be aimed at dispelling early negative perceptions of automated meters and addressing the inherent complexities of replacing a current technology with a more advanced, but relatively new technology. It is important to note that this paper was written in May of 2010 – a full seven years ago. Since that time, grid technology has evolved dramatically. AMI is now a mainstream metering system no longer subject to the "start-up" technology type issues that are the thrust of the EPRI white paper.

[3] *See* Woodward Direct at 11-13 and Woodward Exhibit B at 5. Northeast notes in a footnote to its comments (which is omitted by Mr. Woodward in his quote) that "NSTAR Electric and WMECO have deployed Automated Meter Reading ("AMR") drive-by meter reading capabilities deployed throughout their service territories."

Mr. Woodward's selective citations regarding certain specific failures of advanced meters, in my opinion, do not reflect the intent or the conclusion of the white paper: that for utilities with the need for added metering functionality – such as APS's need to integrate significant amounts of renewable distributed generation – the transition to advanced metering is not a choice, but a necessity.[4]

VII. CONCLUSION

Q. DO YOU HAVE ANY FINAL COMMENTS?

A. APS is one of many utilities around the country working toward a modernized grid that will seamlessly integrate distributed energy technologies, increase reliability and security of energy delivery while providing greater control and choice to utility customers. AMI is one of the cornerstone technologies that is vital to enabling this modern grid.

The Company's AMI is now fully deployed, and our customers are currently experiencing the many advantages of this technology. AMI is providing our customers with greater insight into their energy usage and providing APS with the data necessary to develop new rates and programs to meet customer needs now and in the future. APS understands that despite the many benefits of AMI, some customers would prefer to not have an AMI meter, and therefore the Commission should approve the opt-out program and charges as agreed to in the Agreement.

Q. DOES THIS CONCLUDE YOUR SETTLEMENT REBUTTAL TESTIMONY?

A. Yes.

[4] *See* Woodward Exhibit V at 258. In fact, the final sentence of the EPRI white paper reads "When advanced metering functions are needed, reverting to electromechanical meters is not a viable option."

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ARIZONA CORPORATION COMMISSION

JODI A. JERICH
Executive Director
jjerich@azcc.gov
602-542-3931

To: Docket Control

From: Jodi Jerich, Executive Director

Date: November 4, 2014

Re: **Docket No: E-00000C-11-0328, the Generic Docket for the Commission's Inquiry Into Smart Meters**

ORIGINAL

At the August 5, 2013 Commission Staff Open Meeting, the Commission voted to request the Arizona Department of Health Services to conduct a study on the potential health effects of exposure to radio frequencies emitted from Smart Meters and to docket its report in Docket No. E-00000C-11-0328. I have received that report.

Please docket the attached "Public Health Evaluation of Radio Frequency Exposure from Electronic Meters" authored by the Arizona Department of Health, Office of Environmental Health.

An original and thirteen (13) copies were docketed with Docket Control with copies mailed to the Service List (Attached).

Copy of the foregoing mailed this

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Public Health Evaluation of Radio Frequency Exposure from Electronic Meters

October 31, 2014

Office of Environmental Health

Arizona Department of Health Services

Introduction

A "smart meter" is a term that typically refers to electronic meters that have a two-way communication function between the utility company and the customer. Arizona citizens have been concerned about the potential health effects from exposure to radiofrequency (RF) emitted from Smart Meters. In order to address the customer concerns, the Arizona Corporation Commission (ACC) has requested a review of smart meters used in Arizona. This review is to include a survey of meters used in Arizona to determine whether they emit RF within the Federal Communications Commission (FCC) guidelines, and an evaluation on the potential health risks of RF radiation from the smart meters. In Arizona, there are multiple metering technologies used, and not all types will have and/or utilize the two-way communication function. For the purpose of this report, Arizona Department of Health Services (ADHS) will refer to all wireless communicating meters as electronic meters, regardless of the communication function. The ACC provided comments on the goals and scope of this project, but relied on ADHS and the Arizona Radiation Regulatory Agency (ARRA) for their areas of expertise. The Environmental Toxicology Program in the Office of Environmental Health at the Arizona Department of Health Services conducts risk assessments to determine potential public health impact from site-related contamination. At the request of other agencies or the public, the Environmental Toxicology Program reviews available environmental and exposure data to evaluate potential community exposures to hazardous substances. ADHS does not collect new environmental data, but instead, relies on other agencies or third parties to collect the data.

ARRA houses the nonionizing radiation section, which enforces Arizona Administrative Code Title 12 Chapter 1, Article 14 "The Control of Nonionizing Radiation." These rules address sources of radiofrequency radiation (RF) in the environment, occupational exposure concerns, as well as public exposure. ARRA regulates Class 3B and Class 4 lasers used in the medical, industrial and light show fields, Ultraviolet radiation in tanning facilities, RF radiation sources such as heat sealers and industrial oven, RF radiation in the industrial environment within a frequency range of 0.3 megahertz (MHz) to 100 gigahertz (GHz), and communication sources through a registration/license program. ARRA does not have regulatory authority to enforce rules regarding electronic meters. However, they have the expertise, experience, and ability to measure RF emitting devices including electronic meters.

The goals of this report are 1) to determine whether RF exposure from electronic meters on residences, including single family homes and apartment complexes are within the FCC standards or are at levels to cause public health concern; and 2) to determine whether the current body of peer-reviewed literature has found an association between RF exposure from low level RF exposure and adverse health effects. ADHS reviewed available peer-reviewed literature to summarize potential health effects from radio frequency exposure, including exposure from electronic meters. ADHS also conducted a literature review of standards and guidelines for RF radiation used by a number of countries and health organizations and reviewed the personal anecdotes and journal articles submitted by concerned citizens. Finally, ADHS reviewed RF data collected from various meter types in Arizona to determine if the measured radio frequency is a public health concern.

Background:

What is EMF/RF?

Electromagnetic field (EMF) radiation consists of waves of electric and magnetic energy moving together through space at the speed of light (FCC 2012). Radio waves and microwaves, emitted by transmitting antennas, are one form of electromagnetic radiation and are collectively referred to as "radiofrequency" or "RF" energy or radiation. The most important use for RF energy is in providing telecommunications services. Smart meters, cell phones, Wi-Fi routers, computers, and radio and television broadcasting are just a few of the many telecommunications applications of RF energy.

How is radio frequency measured?

Radiofrequency has two components: an electric and magnetic component. A common unit for characterizing the total electromagnetic field is "power density," which is defined as power per unit area. It is commonly expressed in terms of watts per square meter (W/m^2) (FCC 2012). The quantity used to measure the rate at which RF energy is actually absorbed in a body is called the "Specific Absorption Rate" or "SAR," which is usually expressed in units of watts per kilogram (W/kg). In the case of exposure of the whole body, an adult absorbs RF energy at a maximum rate when the frequency of the RF radiation is approximately 70 MHz. Because of this "resonance phenomenon," RF safety standards are generally most restrictive in the frequency range of 30-300 MHz (FCC 2012).

How do electronic meters use radio frequency?

This report focuses on the usage of electronic meters. Electronic meters give utilities a means to match energy consumption with energy generation, and allow consumers to better manage their energy use. Four general types of meters are used in Arizona. The oldest meter type is analog, which displays energy usage on dials on the face of the meter. Power Line Carriers (PLCs) communicate with the electric company by using power lines, and do not use RF frequencies for communication. Automated Meter Reading (AMR) meters are one-way communicating meters that use RF frequencies to communicate usage data to the electric companies. Advanced Metering Infrastructure (AMI) meters are devices capable of two-way communication, and use RF frequencies for communication purposes. AMI meters send usage data to the electric company, and the electric companies can communicate with the meter, for example, starting and stopping service remotely.

Table 1. Metering technologies evaluated in this study

Type of Meter	Description	Frequency
Analog	The most common type of analog meter is essentially an electric induction motor that drives a series of geared wheels connected to indicators on the meter's face. The utility sends meter readers periodically to each meter, and no RF frequency is used.	N/A
Power Line Carrier (PLC)	Power-line communications usually operate by adding a modulated carrier signal to the existing home electrical wiring system. A PLC carries data on a conductor that is also used simultaneously for alternating current (AC) electric power	57-63 Hz

	transmission or distribution to consumers.	
One-way Communicating [Electronic Meter]	Known as Automated Meter Reading (AMR), these systems consist of small, low-power radio transmitters connected to individual meters that send daily readings to a network of receivers (NYC 2014).	902 – 928 MHz
Two-way Communicating [Electronic Meter] [Smart Meter]	Known as Advanced Metering Infrastructure (AMI), the meters record consumption of electric energy in intervals of an hour or less and communicate that information at least daily back to the utility for monitoring and billing purposes.	902 – 928 MHz

What are some other ways the public might come into contact with radio frequency on a daily basis?

Radio frequency can be from natural sources (e.g. the sun) or from man-made sources (e.g. radios). Some common household items use RF and are regulated by the FCC. The radio frequency ranges emitted from some of the most common RF sources are presented in the diagram below:

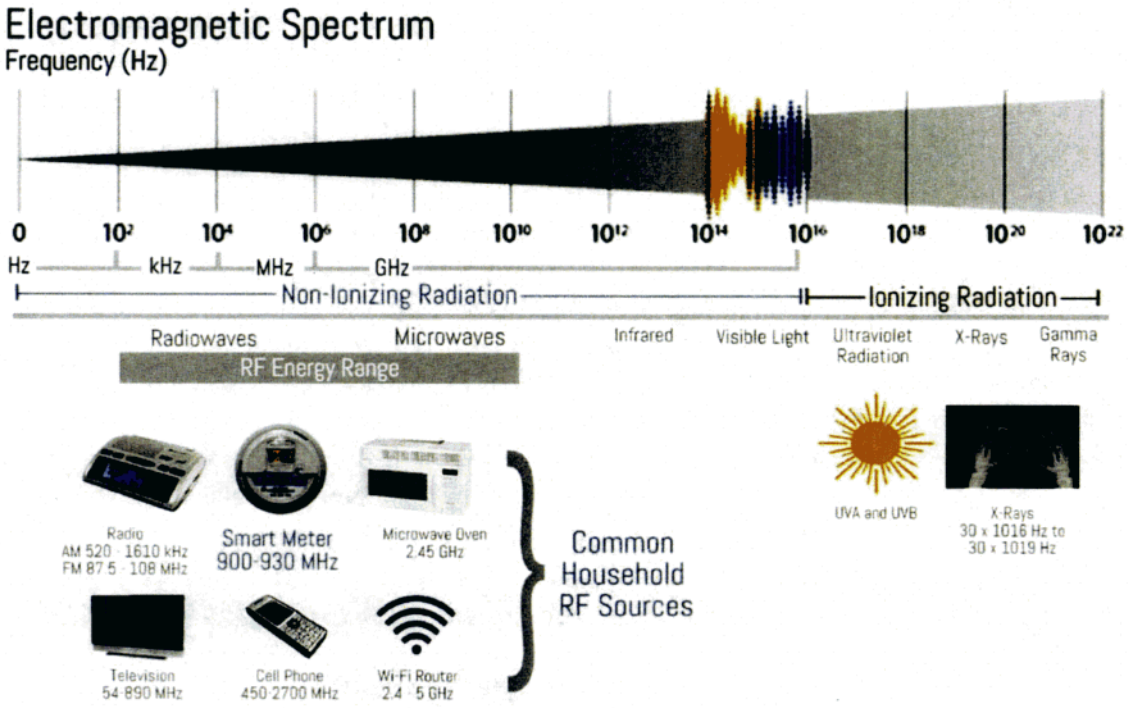


Figure 1. Electromagnetic Spectrum and RF Sources

*Adapted from **the National Institute of Environmental Health Sciences** Electromagnetic Spectrum

What regulations have been developed to limit RF exposure?

The strength of RF exposure from a source can depend on a number of factors. Some of these are discussed below:

- **Power Density:** Some devices emit radiation at higher power densities than others. For example, cell phones and microwave ovens emit radiation at higher power densities than Wi-Fi routers, radios, and smart meters.
- **Distance from radiation signal:** RF exposure decreases rapidly with distance. For the example of microwave ovens, a person 50 cm from a microwave oven receives about 1/100th of the microwave exposure of a person 5 cm away. (WHO 2005)
- **Duration of signal:** Americans spend on average nearly 3 hours per day on their mobile device per day. (Geekwire 2014) In contrast, smart meters in Arizona typically emit RF less than 1/2 hour in total during the day.
- **Attenuation factors:** Attenuation is simply a reduction of signal strength during transmission. Walls, doors, elevator shafts, people, and other obstacles offer varying degrees of attenuation (Moonblink 2014).
- **RF from the Sun:** Humans can also receive RF radiation from the sun. However, this radiation is at a different frequency from radio waves and microwaves.

What are some potential health effects from radio frequency?

Biological effects can result from exposure to RF energy. Exposure to very high RF power densities can result in the heating of biological tissue and an increase in body temperature as a result of thermal radiation (thermal health effects). This can lead to tissue damage, particularly in the eyes and testes (FCC 2012). At relatively low levels of exposure to RF radiation, the evidence for production of adverse health effects is unproven, but there has been concern over non-thermal health effects. A number of individuals have reported a variety of health problems that they relate to exposure to EMF. Some report being so severely affected that they cease work and change their entire lifestyle. This reported sensitivity to EMF has been generally termed "electromagnetic hypersensitivity" or EHS. A survey of occupational medical centers estimated the prevalence of EHS to be a few individuals per million in the population (WHO 2005).

Part 1: Review of Radio Frequency Regulations and Literature

US Regulatory Standard

ADHS searched for regulatory standards developed and/or adopted by the United States Federal Communications Commission (FCC). The Federal Communications Commission (FCC) is an independent agency of the United States government that regulates interstate communications by radio, television, wire, satellite, and cable in the US.

The current exposure limit (Table 2) was determined based on the recommendation made by the International Commission on Non-Ionizing Radiation Protection and the Institute of Electrical and Electronics Engineers, Inc. (IEEE). The ICNIRP and IEEE determined the exposure limits (for occupational and for the general public/community) based on the lowest RF exposure that can cause biological effects. A safety factor was used to derive the values for Maximum Permissible Exposure (MPE) for electric and magnetic field strength and power density. The FCC adopted these values in 1996.

The time-averaging concept can be used to determine the levels of exposure. This means that it is acceptable to exceed the recommended limits for short periods of time as long as the average exposure does not exceed the limit.

Guidelines are more restrictive for lower radio frequencies. Since the smart meters of interest operate between frequencies of 900 and 930MHz, all of the guidelines for power densities presented in Table 2 were calculated assuming a frequency of 900MHz to be most conservative. All standards referenced in this report are based on community exposure, which considered sensitive populations, including children and the elderly. For a discussion of the inclusion of non-thermal effects, see this statement made by the Institute of Electrical and Electronics Engineers (IEEE):

> "Some investigators have reported effects at much lower exposure levels, which are sometimes called 'non-thermal' effects. Each version of the IEEE standard has acknowledged the existence of such reports, while at the same time indicating that they were insufficient to be considered a health hazard or to be used as a basis to develop exposure guidelines. For example, the 1991 standard states that 'research on the effects of chronic exposure and speculations on the biological significance of non-thermal interactions have not yet resulted in any meaningful basis for alteration of the standard. It remains to be seen what future research may produce for consideration at the time of the next revision of this standard.' Other organizations have independently reached this same conclusion" (Ziskin 2005).

Review of Other Standards and Recommendations

ADHS directed a review of standards and guidelines for RF radiation used by a number of countries and health organizations. ADHS found standards for Australia, Canada, ICNIRP, IEEE, New Zealand, and Russia which also included a discussion of how they arrived at their standard.

In North America and most of Europe, exposure standards and guidelines have been based on exposure levels where harmful effects to humans occur. FCC safety factors are then incorporated to determine specific levels of exposure aimed to provide sufficient protection for various segments of the population (including children, the elderly, etc.). Some published limits in other countries have been more restrictive than existing or proposed recommendations for exposure developed in North America and other parts of Europe.

The FCC (USA), Canada, Australia, and New Zealand all based their guidelines on the recommendations of the International Commission on Non-Ionizing Radiation Protection (ICNIRP)'s guideline. The main reason for slight differences in guidelines between these countries is for differences in the safety factors used.

Table 2. Standards and Recommended Guidelines for 900 MHz Radio Frequency		
Country/Organization	**Standard/Guideline for Power Density**	**Citation**
Federal Communications Commission (FCC, USA)	6 W/m^2 (Watts/square meter)	OET Bulletin 56: Fourth Edition, August 1999[1]
Australia	9 W/m^2	Radiation Protection Standard, May 2002[2]
Canada	4.5 W/m^2	Safety Code 6, 2009[3]
International Commission on Non-Ionizing Radiation Protection (ICNIRP)	4.5 W/m^2	ICNIRP Guidelines for Limiting Exposure..., 1998[4]
Institute of Electrical and Electronics Engineers (IEEE)	4.5 W/m^2	IEEE Exposure Limits..., 2005[5]
New Zealand	0.5 W/m^2	Radiofrequency Fields Exposure Standard, Feb. 2014[6]
Russia	0.1 W/m^2	Scientific basis for Soviet and Russian Radiofrequency Standards..., July 2012[7]

Links: [1]FCC [2]Australia [3]Canada [4]ICNIRP [5]IEEE [6]New Zealand [7]Russia

International Commission on Non-Ionizing Radiation Protection (ICNIRP):

The ICNIRP is an independent non-profit scientific organization chartered in Germany, which specializes in non-ionizing radiation protection. Their guideline is based on the study: "Biological Effects and Health Hazards of RF and MW Energy: Fundamentals and Overall Phenomenology" by Sol M. Michaelson. Russia's guideline of 0.1 W/m^2 was based on the study: "Biological Significance of Autoimmune Reactions of the Organism After Exposure to Environmental Factors" by G. I. Vinogradov (in Russian).

This study reviewed a number of studies on animals, including rats and rabbits. It was found from this animal data that exposure to more intense fields, producing Specific Absorption Rate (SAR) values in excess of 4 W/kg, can overwhelm the thermoregulatory capacity of the body and produce harmful levels of tissue heating. The sensitivity of various types of tissue to thermal damage varies widely, but the threshold for irreversible effects in even the most sensitive tissues is greater than 4 W/kg under normal environmental conditions. These data form the basis for an occupational exposure restriction of 0.4 W/kg and a community exposure restriction of 0.08 W/kg, which provide a large margin of safety for other limiting conditions such as high ambient temperature, humidity, or level of physical activity (ICNIRP 1998). These values can then be converted from SAR to their equivalent power density.

The Institute of Electrical and Electronics Engineers (IEEE):

The Institute of Electrical and Electronics Engineers (IEEE) is a professional association, whose objectives are the educational and technical advancement of electrical and electronic

engineering, telecommunications, computer engineering, and allied disciplines. The guideline determined by IEEE has a similar rational to that of ICNIRP, but was developed using different processes. Based on its review, IEEE concluded that disruption of food-motivated learned behavior in laboratory animals is the most sensitive biological response that is both well confirmed and predictive of hazard. This effect, known as behavioral disruption, has been observed in laboratory animals ranging from rodents to monkeys exposed to RF fields at frequencies ranging from 225 MHz to 5.8 GHz. Depending on the animal species and RF frequency, the exposure needed to produce behavioral disruption varied from 3.2 to 8 W/kg (Ziskin 2005).

From its literature review, IEEE chose a value of 4 W/kg for the whole body averaged SAR as the threshold for behavioral disruption in animals. It reduced this SAR by a factor of 10 to establish the basic restriction for exposure in controlled environments, and then added another factor of 5 for exposure in uncontrolled environments. The resulting basic restrictions on whole body SAR are 0.4 W/kg for controlled environments, and 0.08 W/kg for uncontrolled environments. These values can then be converted from SAR to their equivalent power density. For 900 MHz radio frequency, the equivalent power density is 4.5 W/m^2.

Russia:

Radiofrequency (RF) standards for both public and occupational health issued by the Russian Federation have always contained exposure limits that were below those in other countries. Their guideline of 0.1 W/m^2 was based on the study: Vinogradov GI, Naumenko GM, Vinarskaya EM, Gonchar NM. 1987. Biological significance of autoimmune reactions of the organism after exposure to environmental factors. Gig Sanit 1:55-58 (in Russian).

This study reviewed a number of studies on animals, including rabbits, guinea pigs, white rats, wistar rats, and female fisher rats. Based on the immunology studies discussed in the article, chronic daily exposure to 1-5 W/m^2 can induce persistent pathological reactions. The threshold exposure for the unfavorable biological effects (0.5 W/m^2) was found in the immunology studies, but these effects were not pathological since the organisms could compensate for the exposure. The authors concluded, however, continual compensation could lead to long-term adverse effects and thus should be protected against. Chronic exposure to 0.1-0.2 W/m^2 did not induce any noticeable biological changes in small laboratory animals. Therefore the guideline in Russia is 0.1 W/m^2.

Other States' Reviews

Four other states have also conducted various types of studies to evaluate the potential health risk from exposure to radio frequency from electronic meters: Texas, California, Vermont, and Maine. ADHS reviewed those studies and some of the literature referenced in those studies. The Vermont study discussed sampling of electronic meters and identified methods that yielded "worst-case" scenarios. The "worst-case" scenarios identified in Vermont's study were as a starting point for a streamlined sampling approach. More on this is described in the methods of the field study section of this report. ADHS also researched whether any of these states

recommended a more stringent RF standard be applied to electronic meters for the protection of public health.

ADHS reviewed similar assessments performed by other US states and organizations on the potential health effects of RF radiation. Their methods and conclusions are discussed below:

California: In 2010, the California Council on Science and Technology (CCST) performed an "independent, science-based study that would help policy makers and the general public resolve the debate over whether smart meters present a significant risk of adverse health effects." They identified and reviewed over 100 publications and postings about smart meters and other devices in the same range of emissions, including research related to cell phone RF emissions. In addition, they contacted over two dozen experts in radio and electromagnetic emissions and related fields and asked for their opinions. They concluded that:

1. The FCC standard provides an adequate factor of safety against known RF induced health impacts of smart meters and other electronic devices in the same range of RF emissions.
2. At this time, there is no clear evidence that additional standards are needed to protect the public from smart meters or other common household electronic devices (CCST 2010).

Texas: In 2012, the Public Utility Commission of Texas wrote a survey report of the existing scientific research and analyses that have been performed to investigate the potential health effects of exposure to low-level radio frequency electromagnetic fields emitted by wireless communication devices including smart meters. They concluded that:

1. Decades of scientific research have not provided any proven or unambiguous biological effects from exposure to low-level radio frequency signals. All available material was reviewed, and no credible evidence to suggest that smart meters emit harmful amount of EMF radiation was found.
2. Smart meters do not emit or utilize ionizing radiation.
3. Smart meters are not intended for, are not designed to, and do not have the capability to harm an individual or direct a person's thoughts or actions (Rivaldo 2012).

Maine:

A. In 2010, a complaint was filed with the Maine Public Utilities Commission focusing on concerns related to health, safety, and security of smart meters. In response, Maine Center for Disease Control and Prevention (CDC) assembled a "smart meters team" to review numerous materials written by the WHO, FCC, NIH, Health Canada, ICNIRP, IEEE and other government agencies and academic organizations. With regards to electromagnetic hypersensitivity (EHS), the smart meters team concluded that the majority of studies indicate that EHS individuals cannot detect EMF exposure any more accurately than non-EHS individuals, and that well controlled and conducted double-blind studies have shown that symptoms were not correlated with EMF exposure. In summary, they concluded that:

1. Agency assessments and studies do not indicate any consistent or convincing evidence to support a concern for health effects related to the use of radiofrequency in the range of frequencies and power used by smart meters.
2. They also do not indicate an association of EMF exposure and symptoms that have been described as electromagnetic sensitivity (Ball 2010).

B. In 2013, True North Associates was retained by the Office of the Maine Public Advocate to "measure the maximum and average power output of a sample of smart meters and other system components using the mesh network, and compare these readings to existing safety standards." True North focused its efforts on a selection of the most active meters and elements within the mesh network and included all system components involved in broadcasting data within the network. Three residential meter locations were tested. The results obtained through the effort indicated that the measured exposure levels were well below current FCC exposure limits" (C2 Systems 2013).

Vermont:

A. In 2012, the Vermont Department of Health measured RF from smart meters. They stated, "The readings from these devices verify that they emit no more than a small fraction of the RF emitted from a wireless phone, even at very close proximity to the meter, and are well below regulatory limits set by the Federal Communications Commission (FCC). After extensive review of the scientific literature available to date and current FCC regulatory health protection standards, we agree with the opinion of experts:

1. The thermal health effects of RFR are well understood, and are the current basis for regulatory exposure limits. These limits are sufficient to prevent thermal health effects.
2. Non-thermal health effects have been widely studied, but are still theoretical and have not been recognized by experts as a basis for changing regulatory exposure limits" (Vermont 2012)

B. In 2012, the Vermont Department of Public Service aimed to assess compliance of smart meter signal intensities with regulations established by the FCC that prescribe limits for safe exposure to humans. In total, Vermont conducted measurements at 37 different locations in the state, including 18 residential sites, six banks of smart meters, two data collection points, one isolated meter, and 14 general environmental measurement sites. Field measurements were accomplished with a spectrum analyzer based selective radiation meter (Narda model SRM-3000), which permits direct measurement of the intensity of RF fields expressed as a percentage of the FCC maximum permissible exposure (MPE) values. Using the highest indicated results from the measurements performed in the study, it was concluded that:
1. Potential exposure of individuals to RF fields associated with currently deployed smart meters is small when compared to the limits set by the FCC.

2. Any potential exposure to the investigated smart meters will comply with the FCC exposure rules by a wide margin (Tell 2013).

Scientific Publication Review

Review Articles

ADHS performed a literature review of the potential health effects caused by exposure to RF radiation. ADHS searched two different literature databases of peer-reviewed articles. ADHS searched for review articles and articles that discussed an association between RF exposure and any of the top five health concerns from community members (see below). Preference was given to review articles that 1) discussed radiation from electronic meters, and 2) were published within the last 5 years if they could be found.

ADHS found that most experts agree that exposure to RF at high enough strengths for long enough time can result in adverse health outcomes from thermal effects. However, when discussing non-thermal adverse health outcomes, the literature is not clear.

Some study designs reported in the literature provide higher levels of evidence than others. For example, human epidemiology studies are of primary importance in health risk assessment because they can provide direct information on the health of people exposed to an agent. When examining human epidemiology data, systematic review articles which conduct meta-analyses (a statistical technique for combing the findings from independent studies) are the strongest literature. These studies aim for a complete coverage of all relevant studies. They look for the presence of differences, and explore the robustness of the main findings among peer-reviewed scientific studies.

Other literature ADHS reviewed discussed potential changes on the cellular level which provide knowledge of the basic interaction mechanisms of RF with cellular structures. These studies are important hypotheses generating studies. They provide evidence that RF may have the potential to affect human physiology. However, these studies cannot conclude that the cellular changes necessarily lead to disease. Other studies concluded exposure to RF from a variety of sources was associated with adverse health outcomes. However, these studies had several limitations ranging from recall bias to a lack of details, e.g. power densities of exposure or differentiating between exposure to electronic meters and other types of RF emitting devices. Sometimes a study that suggests an exposure is associated with an adverse health outcome is countered by another similar study that suggests there is no adverse health outcome at that exposure level.

ADHS considered articles' study design, exposure parameters, and relevance to this current review. The study design and exposure parameters vary widely from study to study. ADHS attempted to concentrate on those studies that addressed the questions relating to community exposure to RF from electronic meters.

It is generally well understood that RF exposure can cause tissue heating or "thermal effects," leading to potential adverse health effects. More recently, concern has been raised that exposure to lower power densities of RF may lead to adverse health effects without tissue heating, also known as "non-thermal effects." Several studies in the last decade have concluded that RF exposure at lower power densities than those required to cause thermal effects may cause adverse health effects including genotoxicity, decreased sperm count, headaches, sleep problems, concentration problems, and hyperactivity in children. The studies that draw these conclusions are largely based on exposure to cell phones and Wi-Fi devices held close to the human body such as a laptop on a man's lap leading to decreased sperm quality/count. In addition, many of these conclusions were based on results that showed biologic changes. Biologic changes do not always lead to the expected adverse health outcome. The National Aeronautics and Space Administration (NASA) describes the difference of biologic and adverse effects as follows:

> "Biological effect — A biological effect is an established effect caused by, or in response to, exposure to a biological, chemical, or physical agent, including electromagnetic energy. Biological effects are alterations of the structure, metabolism, or functions of a whole organism, its organs, tissues, and cells. Biological effects can occur without harming health and can be beneficial. Biological effects also can include sensation phenomena and adaptive responses.
>
> Adverse health effect — A biological effect characterized by a harmful change in health." (NASA, 2014)

For example Juutilainen, et. al. reviewed *in vitro*, *in vivo*, and human studies on a variety of adverse health outcomes. The authors stated, "the studies discussed in this review indicate that there may be specific effects from amplitude-modulated RF electromagnetic fields on the human central nervous system. The effects reported (changes in EEG, cerebral blood flow and performance in a memory test) are relatively minor, and do not at present allow conclusions concerning possible adverse health effects." They went on to say:

> "Further studies are warranted to determine how the effects depend on modulation characteristics and exposure level, and to investigate possible mechanisms and relevance to human health. Also, animal studies with suitable experimental models would be valuable to shed light on the mechanisms of the modulation-dependent effects on the central nervous system.
>
> No consistent evidence has been found for modulation-dependent effects on carcinogenesis or genotoxicity. Some in vitro studies have provided suggestive evidence of modulation-specific effects at the cellular level. Follow-up of the positive findings would be helpful for

understanding the mechanisms of any specific effects of modulated RF energy."

An international group of researchers reported in L. Verschaeve et. al. the endpoint, exposure conditions, and conclusions for 82 genotoxic endpoints from *in vitro* (lab studies, eg. cells in a petri dish), 29 animal, and 17 human from various studies on RF exposure. The authors concluded that the majority of studies that showed positive results (RF exposure lead to an adverse outcome) reported high exposure levels and the effects were likely due to thermal effects. They also stated that although there were some studies that suggested adverse outcomes from lower level exposure to RF, this apparent association might be due to many factors including poor study design, errors, or incorrect assumptions regarding exposure conditions. Their overall conclusion was "overall, taking into account these different factors the evidence to date that exposure to non-thermal levels of RFR is genotoxic is very weak." The authors also stated, "the weight of scientific evidence from 45 peer reviewed investigations shows that RFR-exposure up to lifetime duration (2 years) does not adversely affect body mass, survival and carcinogenic processes (initiation, promotion or co-promotion) at whole-body dose rates up to 4W/kg and localized dose rates up to 2.3W/kg.

Kundi et al. (2010) reviewed nine epidemiological studies conducted by various countries: US, Sweden, Denmark, Finland, and Germany. These studies investigated the relationship between the use of cell phones and cancer, mainly brain tumors. They concluded that, based on the available information, an elevated cancer risk associated with cell phone use cannot be ruled out because increased cancer risks were observed in epidemiological studies. Yet, all studies have some methodological deficiencies: (1) short exposure duration: the duration of cell phone use were too short to be helpful in risk assessment, (2) exposure was not rigorously determined, and (3) there is a possibility of recall and response error (recall bias) in some studies. Recall bias occurs when the participants recall exposure differently. For example: cancer cases may try harder to recall prior exposure because they think the exposure might be related to their disease. Parents of children with birth effects may try harder to recall any drugs, exposures they had during pregnancy than parents of children without birth defects.

Roosli (2008) conducted a systemic review of electromagnetic sensibility (i.e. the ability to perceive low levels of EMF) and electromagnetic sensitivity (i.e. the development of health symptoms attributing to exposure to EMF such as headache, sleep disturbance, fatigue, dizziness, and concentration difficulties.) Meta-analytic techniques were used to analyze and integrate the information from peer-reviewed articles published before 2007. For electromagnetic sensibility, the author reviewed seven studies including a total of 182 self-declared electromagnetic hypersensitivity (EHS) individuals and 332 non-EHS individuals. The results indicated that there was no evidence that EHS individuals could detect presence or absence of EMF better than other persons. For electromagnetic sensitivity, the review from eight laboratory studies (including 194 EHS and 346 non-EHS individuals) showed that there was little evidence that short-term exposure to a mobile phone or based station causes non-specific symptoms. Four population-based studies were reviewed. Two studies observed slightly

increased, but not significant, complaints while the other two studies found there is no association. Overall, this review concluded that: the large majority of individuals who claim to be able to detect low level of radio frequency EMF are not able to do so under double-blind conditions.

In another study, Karaca et. al. (2012) stated that "the results of our study support the proposition that cell phones may have a potential to cause hazardous effects on the genome; however, in *in vivo* conditions, the duration of exposure and the capacity of DNA repair may prevent the development of cancer to an extent."

Vigjayalaxmi compiled the conclusions on the biological effects of RF exposures from various national and international expert groups. Below is a summary table of these conclusions (2014).

Organization	Conclusions
IARC	No increased risk for meningioma and glioma with mobile phone use.
IEEE	Public health officials should continue to use RF safety limits of international organizations.
ICNIRP	Impossible to disprove non-thermal effects. Poor evidence for chronic/low-level effects. Studies with adequate RF exposure assessment did not reveal any health-related effects.
EU	No consistent evidence on cognitive function. No clear effect on neurological diseases. Inadequate evidence for cancer and neurological diseases.
Australia	No substantiated evidence for health risk for people living near base stations. Insufficient evidence for higher risk for children. No need to reconsider exposure limits.
Belgium	No proven health risks. Long-term health risks cannot be ruled out.
Canada	Cell phone towers are not dangerous. No evidence of adverse effects from WiFi.
Finland	Mobile phone use is not detrimental to health.
France	No new proven health effects.
Germany	Discrepancy between scientific evidence and risk perception. No overall risks. Risk perception is linked to media coverage.
Latin America	Insufficient evidence for adverse health effects from in vitro and in vivo studies.
Netherlands	Insufficient and inconsistent association of tumors in brain and other regions of head.
New Zealand	No health problems when complied with international guidelines.
Nordic Countries	No scientific evidence for adverse health effects.
Norway	No evidence that weak RF fields cause adverse health effects. Uncertainty in risk assessment is small.
Spain	No scientific evidence that exposure to low emissions levels produces adverse health effects in school children.
Sweden	Overall data do not support increased cancer risk in mobile phone users.
Switzerland	No new confirmed health effects.
Tanzania	No substantial evidence for harmful health effects. Many benefits of modern technology.
UK	No convincing evidence in adults or children for adverse effects below the

	recommended/guideline levels.
USA	Studies have not shown a consistent link with cancers of the brain, nerves, or other tissues of the head and neck cancers.

Source: Vijayalaxmi. "International and National Expert Group Evaluations: Biological/Health Effects of Radiofrequency Fields." International Journal of Environmental Research and Public Health: Volume 11, Issue 9. September 10, 2014.

Another review article summarizes that excessive exposure to magnetic fields from power lines and other sources of electric current increases the risk of development of some cancers and neurodegenerative diseases. Excessive exposure to RF radiation increases risk of cancer, male infertility, and neurobehavioral abnormalities. Smart meters usually produce atypical, relatively potent, and short-pulsed RF microwaves whose biological effects have never been fully tested and may, in fact, be more hazardous than other waveforms. Electronic meters can add significantly to aggregate RF exposure.

However, at further study of the article, the article states that a typical electronic meter with a 5% duty cycle at a distance of 20 cm (= 0.656 ft) emits 11 $\mu W/cm^2$ of RF radiation. This is equal to 0.11 W/m^2, which is well below the FCC community guideline of 6 W/m^2. The article seems more focused on the dangers of cell phone radiation, which is a separate issue (Carpenter, 2013).

Whether a person experiences an adverse health outcome from RF depends on many factors. Factors include how strong the power density is, how far the person is from the RF field, how often the person is exposed, and the individual health of the person exposed.

Individual Health Effects

ADHS conducted a literature search of peer-reviewed articles on the potential effects of RF radiation. Special attention was given to articles that discussed the health concerns most noted by Arizona citizens. These health effects are: headaches, insomnia, cancer, ear pain/tinnitus, and fatigue. Preference was given to articles that 1) discussed radiation from electronic meters, and 2) were published within the last 5 years.

The articles ADHS found discussed RF from sources other than electronic meters. A number of the articles discussed the potential health effects listed above from RF radiation emitted from cell phones. Electronic meters use a very similar wireless technology to cell phones, and the electronic meters in Arizona use a frequency of 900-930 MHz, which is within the frequency range of cell phones (450-2700 MHz). However, strength of the RF field and exposure to electronic meters and cell phones differ.

Most of the studies concluded that there was no association between RF exposure at low levels and adverse health outcomes. A couple of articles found weak associations. Some studies called for additional research (Mohler, 2012; Lowden 2011; Heinrich 2010; Mortazavi 2014; Poulsen 2013; Swerdlow 2011; Kwon 2012; Choi 2014; and Frei 2012).

Submissions from the Community

Arizona residents have submitted a plethora of information to the Arizona Corporation Commission's eDocket relating to RF exposures from electronic meters. ADHS reviewed the documents submitted from August 2011 to August 2014 that discussed health-related concerns. ADHS also reviewed direct communication received before October 1, 2014 from community members across the state. The types of information submitted by residents included news articles, websites, peer-reviewed studies, documents released by governmental regulatory or advisory bodies, anecdotal descriptions of how residents believed electronic meters were affecting their health, and personal opinions. ADHS reviewed the peer-reviewed studies and government documents. A discussion on some of these is included in the literature review section described above. ADHS created a table of the reported health effects, and made note of how many times each effect was mentioned. ADHS determined the top 5 mentioned health effects and searched peer-reviewed literature databases (described above) for peer-reviewed studies that looked for associations between RF exposure and the reported health effect. A list of the reported health concerns can be found in Appendix A.

ADHS reviewed all 38 journal articles assessing health implications that were submitted to the ACCs eDocket. ADHS provides a summary and response to the three were most often mentioned articles in Appendix B.

Health Concerns Mentioned in Submissions to the ACC eDocket		Number of times mentioned
Top Five Concerns	Headaches	28
	Insomnia	27
	Cancer	15
	Fatigue	14
	Ear pain/ringing (tinnitus)	14

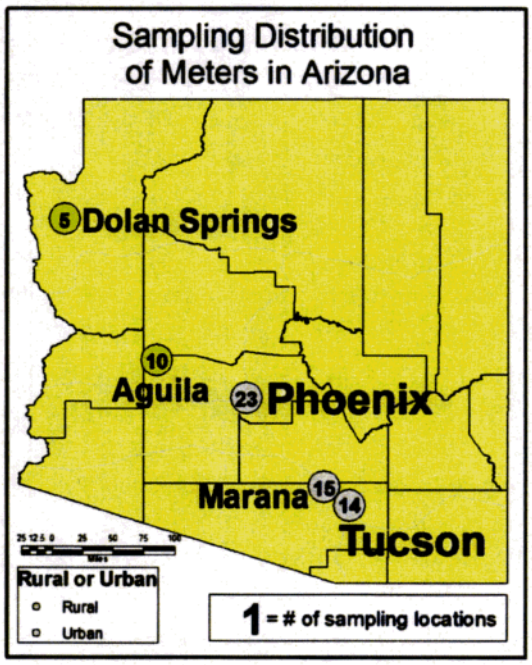
Part 2: Field Study

ADHS worked with ARRA to design a field sampling plan that would measure different meter technologies in urban and rural areas. The agencies used their expertise and referred to previous studies to identify a scientifically sound method. The agencies approached the field study by attempting to capture a worst case scenario as a screening process. If a measurement was captured at or above the screening value, a more in depth evaluation would be necessary. The field study was not intended to strictly follow FCC's recommendations for evaluating human exposures to RF, but rather capture the worst case scenario. The FCC guidelines consider percent Maximum Permissible Exposure (MPE) and duty cycle when comparing the measured RF exposure to the standard. This study measured peak and average power densities at 5, 10, and 15 minutes without regard to duty cycle.

It was decided that ARRA would test the RF emitted from a variety of meter technologies: analog, PLC, AMR and AMI. The Arizona Radiation Regulatory Agency (ARRA) conducted the field sampling analyzed in this report. ADHS used the measured RF levels to determine if there is a public health concern associated with exposures to electronic meters in Arizona. Sampling was conducted from June to September 2014 by ARRA. Only outdoor sampling was conducted at residential locations for single-family homes and apartment complexes.

Selecting sampling locations

Sampling locations were selected by the technology of the meter used by the electric companies for the three technologies: AMI, AMR, and PLC. 2010 U.S. Census Bureau definitions were used to identify whether a city was considered urban or rural. Locations that were serviced by each the three technologies were randomly chosen to identify five zip codes for testing (3 urban zip codes and 2 rural zip codes). The following cities and zip codes were selected for field sampling: Phoenix (85023), Aguila (85320), Tucson (85712), Dolan Springs (86441), and Marana (85658). ADHS contacted the electric companies for the zip codes selected for field sampling. ADHS requested all addresses within the zip code that have the technology being sampled. This was to ensure the chosen sampling locations would be operating as regularly scheduled. ADHS randomly selected addresses on the lists provided by the electric companies to create a description of neighborhoods (street names and names of apartment complexes) for ARRA to sample. ARRA then selected addresses from the neighborhood descriptions provided by ADHS.



Number of samples

ACC and ARRA worked together to determine the scope of the sampling. ARRA tested as many sampling locations in each of the zip codes as was feasible for the scope of the project. There were a total of 66 sampling locations: 10 locations were apartments, 2 locations were part of duplexes, and 54 were single- family residences.

Radiofrequency Sampling Device

The Tenmars TM-195 is a radio frequency (RF) field strength meter. It is designed for measuring and monitoring RF electromagnetic field strength over the frequency range of 50 megahertz through 3.5 gigahertz. This meter self-calibrates at power up levels but has a functionality to be manually adjusted to detect more sensitive frequencies inside of multiple frequency fields. Field strength meters will display excessive values if hand-held or moved during measurements from electrostatic charges. To counter this, the TM-195 should be used on a tripod or held as steady as possible while avoiding speaking or moving during measurements. The electrical specifications are as follows:

Under the following conditions:
Ambient temperature +23°C ± 3°C
Relative Humidity 25% - 75%
Frequency range 50 megahertz – 3.5 gigahertz
CW signal (f>50 megahertz) 0.01V/m to 20.0 V/m
0.1 mA/m to 532.6 mA/m, 0.01W/m² to 106.94mW/m²
Dynamic range: Typically 75 dB
Absolute error at 1 V/m and 2.45GHz ± 1.0 dB

Frequency response:
Sensor taking into account typical CAL factor
± 2.4dB (50 Mhz to 1.9 GHz)
± 1.0 dB (1.9 GHz to 3.5 GHz)
Isotropy deviation: Typically ± 1.0 dB (f 2.45GHz)
Overload limit: .042 mW/cm²
Overload limit: (0 to 50°C); ± .2 dB

The Arizona Radiation Regulatory Agency uses this meter during routine use to ensure that industrial registrants registered to operate radio frequency devices do not exceed the maximum permissible exposure (MPE) limits as defined in the Arizona Administrative Code Title 12, Chapter 1, Article 14. Calculations of the MPE are published in IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

Sampling Design

The measurements of RF can be affected by various factors: traffic on the meter network, proximity to other meters, background RF, direct sunlight, barriers between the meter and the RF sampling device/person. These factors were considered in the design of the sampling plan.

Trial Sampling Event

A trial sampling event was conducted at a residential, single-family home and an apartment complex to determine the feasibility of various sampling parameters. At this event, two distances (three feet and nine feet), use of attenuation and no attenuation, and time intervals (readings every 15 minutes for one hour) were considered. It was determined that spending one hour at each location would significantly limit the number of total sampling locations in the final review. In order to 1) sample more locations, 2) measure the same location multiple times at different times of the day, and 3) sample locations across the state, it was decided to adjust the sampling parameters to measure the maximum radiofrequency a person may be exposed to from the electric meter, the worst-case scenario.

Vermont's Study

Richard Tell Associates, Inc. conducted a field study of electronic meters deployed in Vermont. During this field study, they sampled a residential meter to assess the potential exposure and directionality to electronic meter RF fields at various distances, heights, and horizontal directions. Readings were taken at four distances between one foot and 10 feet, with the highest reading occurring at a distance of one foot. For height, the measurement at four feet above the ground (the height of the face of the meter) was the highest reading, suggesting that emissions are mainly directed horizontal to the meter. In the horizontal plane, the highest readings occurred at zero degrees, or forward from the face of the meter. Measurements were also taken inside the home to account for attenuation. Attenuation refers to the concept that RF exposure is less if there is a material between the RF emitting device and the person being exposed.

The findings of Vermont's report were considered in determining the parameters of the "worst case scenario": measurements at one foot, height of the face of the meter, and the sampling device probe aimed at the front of the face of the meter, without any attenuation.

Readings from the TM-195 were taken at five minute intervals, over a 15 minute period. Readings were also taken at three different times during the day to determine if there is any difference in RF transmission throughout the day. Background RF was also measured near sampling locations. This background location was chosen to have as little RF transmission signals as possible, such as being away from overhead power lines, street lights, houses, etc. Background measurements were taken for all sampling locations.

Field Measurements

ARRA completed all field sampling and recorded data on the sampling form created by ADHS see Appendix C. ARRA mutually agreed upon sampling protocols.

Sampling device setup

The TM-195 was secured to a tripod and adjusted to the same height as the center of the face of the meter. For single meters, the probe was directed at the center of the electric meter. For a bank of meters, the probe was directed toward the center of the bank of meters and raised to the height of the middle of the bank of meters. The sampling device was placed one foot away from the electric meter (s), perpendicular to the front face of the meter.

Figure 2. TM-195 placement at a single-family residence.

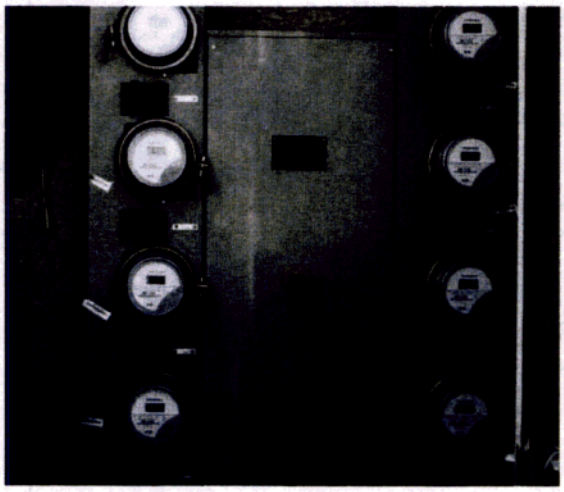


Figure 3. TM-195 placement at a bank of meters.

For each sampling location ARRA:

1. Recorded address location, address type (single family home or apartment complex), zip code (urban or rural area) and meter details [single meter or bank of meters (record number of meters in the bank)], location of meter(s) on the home (garage or living space) and the meter model.
2. Recorded background readings in the shade and sun to the corresponding sampling address location. Recorded average and peak reading over a five minute time interval.
3. Took all measurements at one foot, without attenuation.
4. Recorded the average and peak readings every five minutes for a total of 15 minutes.
5. Sampled at three different times during the day (for example, morning, midday, and afternoon).

For each reading time ARRA:

1. Recorded weather condition (sunny, partly cloudy, or mostly cloudy.)
2. Recorded whether or not the readings were taken in the shade.
3. Recorded dates and times of readings.

Results and discussion

On-site Readings of Radio Frequency Electromagnetic Fields

The RF electromagnetic field emissions associated with the usage of electronic, PLC, and analog meters were measured by using a RF field strength meter, Tenmars TM-195, as described in the Methods section. This field investigation examined the strengths (measured by power density in watts per square meter, W/m^2) of the RF fields emitted by different types of meters under normal operating conditions because the electric companies were not notified when the investigation was conducted. This was determined by the study group (i.e. ACC, ARRA, and ADHS) to prevent bias.

The amount of transmitting activity of an electronic meter varies throughout the day. It depends on the prescribed data-collecting times and the interaction with other meters. In addition, the typical emission of an electronic meter consists of very brief spurts of pulses of RF energy lasting less than one-tenth of a second. To represent the overall exposure throughout a day, power density measurements were taken at three different times during the day (for example, morning, midday, and afternoon) for each sampling location. Both the average and instant peak values of field power density were measured. The measurements were taken at 1 foot away from the meter without attenuation. The measurements represented the maximum RF emission a person (i.e. worst case scenario) can be exposed to from the meters at the sampling time.

ADHS compared the levels of RF power density measured in front of different types of meters (Table 3). As expected the measured RF levels are higher for AMI and AMR meters because they communicate via radio frequency. ADHS compared the levels of RF power density measured in front of single and multiple meters (Table 4.) As expected the measured RF levels are higher for multiple meters. ADHS also compared the levels of RF power density measured at urban and rural areas (Table 5.) Overall, the RF levels are higher in urban area. These results indicated that, under the sampling scenario, people will receive higher levels of RF exposure from multiple meters. Yet, as discussed later, none of the measured RF power density are at levels of public health concern.

Table 3 shows the readings of power density from different types of meters.

Meter Type	Number of meters measured	Range of 5-min average (W/m^2)	Highest reading measured (W/m^2)
Analog	3	0.0000035 – 0.0000879	0.000129
PLC	13	0.0000131 – 0.0000936	0.001084
AMR	17	0.0000021 – 0.000747	0.001435
AMI	33	0.00001 – 0.0016017	0.0025

Table 4 shows the readings from residences with single meters or multiple meters.

Meter Type	Number of meters measured	Range of 5-min average (W/m^2)	Highest reading measured (W/m^2)
Single meter	54	0.000021 – 0.0003	0.0025
Multiple meters	12	0.00001347– 0.0016017	0.0017679

Table 5 shows the readings from urban and rural areas.

Meter Type	Number of meters measured	Range of 5-min average (W/m^2)	Highest reading measured (W/m^2)
Urban	49	0.0000021 – 0.0016017	0.0025
Rural	17	0.0000043 – 0.000163	0.000163

Public Health Implication Based on the On-site Readings

ADHS generally follows a three-step methodology to assess public health issues related to environmental exposures. First, ADHS obtains representative environmental data for the site of concern and compiles a comprehensive list of site-related contaminants or concerns. Second, ADHS identifies exposure pathways, and then uses standards or guidelines to find those exposures that do not have a realistic possibility of causing adverse health effects. For the remaining exposures, ADHS reviews recent scientific studies to determine if exposures are sufficient to impact public health.

These on-site readings were compared to standards and guidelines, which are often used as screening tools to evaluate environmental data relevant to exposure pathways. The standards and guidelines are quite conservative, and include safety factors that account for sensitive populations (such as infants, young children, and elderly.) Adverse health effects are not expected to occur if an exposure level is below a health-based guideline. However, an exposure level at or above the health-based guideline does not mean adverse effects will occur. Rather, it means that there is a need to conduct a site-specific exposure scenario evaluation. The health risk for an individual depends on individual human factors (e.g. personal habits, occupation, and/or overall health), and site-specific environmental exposure factors (e.g. duration and amount of exposure). Therefore, the health-based guidelines should not be used to predict the occurrence of adverse health effects without looking at site-specific conditions.

ADHS typically uses standards and guidelines as follows: if an exposure is never found at levels greater than its standard or guideline, ADHS concludes the levels of corresponding exposure do not pose a risk to human health. If, however, an exposure is found at levels that are greater than its standard or guideline, ADHS examines potential human exposures in greater detail.

Meters communicate via radio frequency (i.e. AMI and AMR meters):

Measured power densities were compared to health-based guidelines (Table 6.) The 30-minute averages were calculated by using the top six 5-minute averages from a sampling location. This approach provided an estimation of the possible maximum 30-minute exposure throughout a day. The overall averages were calculated by using all 5-minute averages from a sampling location. This provided an estimation of the overall exposure throughout a day. ADHS used guidelines developed by FCC, ICNIRP, IEEE and Russia to evaluate the potential adverse health effects associated with exposures to radio frequency from AMI and AMR meters.

Short-term Exposure: FCC, ICNIRP and IEEE guideline values was determined based on established adverse thermal health effects. The purpose of these guidelines are to prevent whole-body heat stress and excessive localized tissue heating. The 30-minute averages ranged from 0.000021 to 0.000465 W/m^2 for AMR meters, and from 0.000028 to 0.001101 W/m^2 for AMI meters. None of these values exceeded the FCC (6 W/m^2), or ICNIRP/IEEE (4.5 W/m^2) guideline values (Table 6.)

Long-term Exposure: FCC does not have an established standard for non-thermal health effects because of insufficient information. Our review of US and most internal government assessments, and scientific publications indicated that there is no consistent or convincing evidence to support a cause-and-effect relationship related to the exposure to the RF frequency (900 – 930 MHz) used by the smart meters. The majority of the scientific studies concentrated on the possible health effects from mobile phone exposure. When compared to mobile phones, smart meters represent lower RF exposure sources because of the attenuation factor of the building structure (for example: walls), and the distance from radiation signal source (i.e. location of the smart meters and mobile phones in relation to the human body.) Based on these, it appears to us that exposures to smart meters would indicate even less association to non-thermal effects.

Our review indicated that Russia has developed a standard for radio frequency between 450 to 2,700 MHz for mobile phones. This standard was determined based on non-thermal health effects. We do not have access and do not have the ability to review the original paper (in Russian). The source indicated that this value was set based on an animal study consisting of 110 rats exposed to 900 and 1,800 MHz at 5 and 20 W/m^2. The results showed changes in the immune status of animals exposed to 5 W/m^2. A safety factor was applied to obtain the Russian standard of 0.1 W/m^2 for the general public. This limit was set to ensure that no exposure would cause any possible biological consequences among the exposed population. ADHS used the Russian standard as a comparison to ARRA's measurements. The results showed that none of the overall average readings of AMI (ranging from 0.000025 to 0.000888 W/m^2) or AMR (ranged from 0.000016 to 0.000377 W/m^2) meters exceeded the standard (Table 6.)

In this field investigation, ARRA measured the RF emission levels based on the worst case scenario. Such measurements do not necessarily reflect personal RF exposure (they tend to overestimate the RF exposures) because they are not always taken at the distance from the RF source that the person would typically be from the source (for example: inside the house.) Therefore, with the available information, exposures to AMI and AMR meters are not likely to harm the health of the public.

Table 6 shows the readings of power density from electronic meters communicating via radio frequency.

Meter Type	Number of meters measured	30-min average (W/m^2)	Highest reading measured (W/m^2)	Standards/ Guidelines (W/m^2)	
AMR[1]	17	0.000021 – 0.000465	0.001435	6	FCC
AMI[2]	33	0.000028 – 0.001101	0.0025	4.5	ICNIRP/IEEE

1. AMR: Automated Meter Reading
2. AMI: Advanced Metering Infrastructure
3. FCC: U.S. Federal Communications Commission OET Bulletin 56, 47 CFR § 1.1310

4. ICNIRP: International Commission on Non-ionizing Radiation Protection
5. IEEE: Institute of Electrical and Electronics Engineers (IEEE)

Meter Type	Number of meters measured	Overall average (W/m^2)	Standards/ Guidelines (W/m^2)	
AMR[1]	17	0.000016 – 0.000377	0.1	Russian
AMI[2]	33	0.000025 – 0.000888		

1. AMR: Automated Meter Reading
2. AMI: Advanced Metering Infrastructure

Meters that do not communicate via radio frequency (i.e. PLC and analog meters): As described in previous sections, analog meters are not expected to emit any radio frequencies. The PLC meters communicate via power lines. During the data transmission process, a power frequency field of 60 Hz is produced. Power frequency is considered as a type of extremely low frequency (ELF) electric and magnetic field ranging from 3 to 3,000 Hz. In this range, electric and magnetic fields do not interrelate as higher-frequency waves (such as radiofrequency), and they are characterized separately. Electric field strength is measured in unit of volts per meter (V/m), and the magnetic field strength is measured in units of gauss (G) or tesla (T.) The strength of power radio frequency was not measured since it is not within the scope of this investigation. A detailed discussion of power line frequency can be obtained from a NIEHS publication[1] (NIEHS 2002.)

For the purpose of comparison, PLC and analog meters were included in the field investigation. Different levels of RF power density were detected from residences with PLC and analog meters during the field investigation. The measured RF levels from residences with analog and PLC meters were comparable to each other (see Table 3), and their respective background levels. For example, the three 5-minute average for one house were 0.0000178, 0.0000159, and 0.0000154 W/m^2. The background level was 0.0000142 W/m^2. The results suggest that only a very little amount of RF may be emitted from PLC meters.

Conclusions

Review of Radio Frequency Regulation and Literature:

ADHS reviewed: (1) regulatory standards developed by the US and other countries such as Australia, Canada, Russia, and New Zealand, (2) exposure recommendations provided by the International Committee on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE), (3) smart meter radio frequency studies conducted by other states such as California, Texas, Maine, and Vermont, (4) peer-reviewed scientific publications, and (5) smart meter and RF

[1] EMF: Electric and Magnetic Field Associated with the Use of Electric Power

exposure related documents submitted to the Arizona Corporation Commission's eDocket. Based on the available information, ADHS found that:

- The majority of the countries determined their standards based on the recommendation of the ICNIP and IEEE. The values of specific absorption rate (SAR) and power density were established to prevent thermal effects from radio frequency radiation. No value was recommended for non-thermal effects because the ICNIP and IEEE, based on the available information, feel that the evidence from epidemiological and laboratory studies are not sufficient to identify there is a health hazard nor to be used as a basis to develop exposure guidelines.
- Russia set a much lower standard which was determined to prevent any possible biological consequences among the exposed population. The study was conducted by Russian scientists and the paper was written in Russian. ADHS was not able to review the report. The source indicated that the value was determined based on chronic immunology studies from a number of animal studies.
- States conducting radio frequency studies have similar findings, based on scientific literature review or field measurements. Their results agreed that the thermal effects of radio frequency are well understood, and the current FCC standard is sufficient to provide an adequate protection to prevent thermal effects. In addition, no sufficient evidence to support a need for additional standards to protect the public from electronic meters.
- ADHS concurs with the findings from the other states. ADHS reviewed articles on the potential health risks from RF radiation, mainly from wireless communication. The review examined the potential biological and health effects from exposure to RF fields from studies that have been published. The authors reviewed relevant research investigations in different areas: epidemiology studies, empirical studies in cell cultures and animals, and clinical human studies. An overall assessment was then conducted based on the aggregated evidence across reviewed areas. ADHS found that most experts agree that exposure to RF at high enough strengths for long enough time can result in adverse health outcomes from thermal effects. However, when discussing non-thermal adverse health outcomes, the literature is not clear.
- ADHS also reviewed articles published in the last five years that discussed the health concerns most noted by Arizona citizens. These health effects are: headaches, insomnia, cancer, ear pain/tinnitus, and fatigue. Most of the studies concluded that there was no association between RF exposure at low levels and adverse health outcomes. A couple of articles found weak associations. Some studies called for additional research.

Field Investigation:

ARRA conducted a field investigation to identify the levels of RF radiation emitted from different types of meters (i.e. analog, PLC, AMI, and AMR meters.) The measurements were taken from single family homes, and apartment complexes at rural and urban areas. After receiving data from ARRA, ADHS conducted an assessment to evaluate the potential health risks associated with exposure to radio frequency radiation emitted from electronic meters (i.e. AMI and AMR meters.) Based on the available information, ADHS reached the following conclusions:

- The measured RF radiation emissions (in power density) from electronic meters are below the FCC standard of 6 watts per square meter (W/m^2).
- In general, the measured RF radiation emissions are higher from AMI and AMR meters. The measured RF radiation emission from analog and PLC meters are similar to the background levels.
- In general, for electronic meters, the measured RF radiation emissions are higher for apartment complexes when they are compared to single family homes.
- In general, for electronic meters, the measured RF radiation emission is higher from urban area when they are compared to those from rural area.
- *Exposure to electric meters (AMI and AMR) is not likely to harm the health of the public.* This conclusion was reached because (1) none of the detected power densities exceeded the FCC standard of 6 W/m^2. This standard was determined based on thermal effects, and was set to prevent whole-body heat stress and excessive localized tissue heating; (2) available government assessments and scientific literature indicated that there is no consistent or convincing evidences to support a cause-and-effect relationship related to the exposures to the RF frequency (900 – 930 MHz) used by the smart meters ; (3) none of the detected power density exceeded the lowest available guideline of 0.1 W/m^2 (determined by Russia.) This value was determined to ensure that no exposure would cause any possible biological consequences among the exposed population.

Works Cited

"About Automated Meter Reading (AMR)." *NYC*. City of New York City Environmental Protection, Web. 15 Oct. 2014. <http://www.nyc.gov/html/dep/html/customer_services/amr_about.shtml>.

Alaxmi, Vijay, and Maria R. Scarfi. "International and National Expert Group Evaluations: Biological/Health Effects of Radiofrequency Fields." International Journal of Environmental Research and Public Health 11.9 (2014): 9376-9408. MDPI. 10 Sept. 2014. Web. 22 Oct. 2014. <http://www.mdpi.com/1660-4601/11/9/9376>."

"Assessment of Demand Response & Advanced Metering." Federal Energy Regulatory Commission, Dec. 2008. Web. 15 Oct. 2014. <http://www.ferc.gov/legal/staff-reports/12-08-demand-response.pdf>.

Ball, Lauren, Nancy Beardsley, Jay Hyland, Dora Anne Mills, Molly Schwenn, and Andy Smith. "Maine CDC Executive Summary of Review of Health Issues Related to Smart Meters." Marblehead Electric, 8 Nov. 2010. Web. 23 Oct. 2014. <http://www.marbleheadelectric.com/MaineonSmartMeters.pdf>.

"Canada's Safety Code 6 Regulations." RF Safety Solutions. Web. 22 Oct. 2014. <http://www.rfsafetysolutions.com/RF%20Radiation%20Pages/Safety_Code_6.html>.

Carpenter, David O. "Human Disease Resulting From Exposure to Electromagnetic Fields." Reviews on Environmental Health 28.4 (2013): 159-72. PubMed, 27 Nov. 2013. Web. 22 Oct. 2014. <http://www.ncbi.nlm.nih.gov/pubmed/24280284>.

Cell Phone Towers and Cell Phones Questions and Answers about Safety. Hartford: Connecticut Dept. of Public Health, Environmental and Occupational Health Assessment. Jan. 2004. Web. 15 Oct. 2014. <http://www.ct.gov/dph/lib/dph/environmental_health/eoha/pdf/cell_phones.pdf>.

Choi, Soo Beom, Min Kyung Kwon, Jai Won Chung, Jee Soo Park, Kil Soo Chung, and Deok Won Kim. "Effects of Short-term Radiation Emitted by WCDMA Mobile Phones on Teenagers and Adults." BMC Public Health 14.438 (2014). Biomed Central, 10 May 2014. Web. 22 Oct. 2014. <http://www.biomedcentral.com/1471-2458/14/438>.

Cleveland, Robert F., Jr., and Jerry L. Ulcek. "Questions Answers About Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields." Federal Communications Commission (FCC), Aug. 1999. Web. 22 Oct. 2014. <http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e4.pdf>.

"Electric Meter." *HowStuffWorks*. HowStuffWorks.com, 25 Aug. 2009. Web. 15 Oct. 2014. <http://science.howstuffworks.com/electric-meter-info.htm>.

"Electromagnetic and Radiofrequency Fields Effect on Human Health."American Academy of Environmental Medicine (2008). American Academy of Environmental Medicine. Web. 22 Oct. 2014. <http://aaemonline.org/emf_rf_position.html>.

"Electromagnetic Fields & Public Health: Microwave Ovens." *World Health Organization*. Feb. 2005. Web. 14 Oct. 2014. <http://www.who.int/peh-emf/publications/facts/info_microwaves/en/>.

"Electromagnetic Fields and Public Health: Mobile Phones." *Media Centre*. World Health Organization, Oct. 2014. Web. 14 Oct. 2014. <http://www.who.int/mediacentre/factsheets/fs193/en/>.

"Electromagnetic Spectrum." National Institute of Environmental Health Services. National Institutes of Health, 25 Aug. 2014. Web. 22 Oct. 2014. <http://www.niehs.nih.gov/health/assets/images/electromagnetic_spectrum.jpg>.

Foster, Kenneth R. "Exposure Limits for Radiofrequency Energy: Three Models." World Health Organization. Web. 22 Oct. 2014. <http://www.who.int/peh-emf/meetings/day2Varna_Foster.pdf>.

"Frequency Asked Questions about Cell Phones and Your Health." Radiation and Your Health. Center for Disease Control and Prevention (CDC), 9 Sept. 2014. Web. 23 Oct. 2014. <http://www.cdc.gov/nceh/radiation/cell_phones_FAQ.html>.

Frei, P., E. Mohler, C. Braun-Fahrlander, J. Frohlich, G. Neubauer, and M. Roosli. "Cohort Study on the Effects of Everyday Life Radio Frequency Electromagnetic Field Exposure on Non-specific Symptoms and Tinnitus." Environment International 38.1 (2012): 29-36. PubMed. Web. 22 Oct. 2014. <http://www.ncbi.nlm.nih.gov/pubmed/21982030>.

Goldsworthy, Andrew. "The Biological Effects of Weak Electromagnetic Fields Problems and Solutions." Federal Communications Commission (FCC), Mar. 2012. Web. 22 Oct. 2014. <http://apps.fcc.gov/ecfs/document/view?id=7022311211>.

Gustavs, Katharina. "Current RF Exposure Limits." Building Biology. Rainbow Consulting. Web. 22 Oct. 2014. <http://buildingbiology.ca/wd/wp-content/uploads/2012/09/2012-8-Cell-Tower-Guidelines.pdf>.

"Health Impacts of Radio Frequency Exposure from Smart Meters." California Council on Science and Technology, Apr. 2011. Web. 23 Oct. 2014. <http://www.ccst.us/publications/2011/2011smart-final.pdf>.

Heinrich, Sabine, Silke Thomas, Christian Heumann, Rudiger Von Kries, and Katja Radon. "Association between Exposure to Radiofrequency Electromagnetic Fields Assessed by Dosimetry and Acute Symptoms in Children and Adolescents: A Population Based Cross-sectional Study." Environmental Health 9.75 (2010). Environmental Health Journal, 25 Nov. 2010. Web. 22 Oct. 2014. <http://www.ehjournal.net/content/9/1/75>.

"ICNIRP Guidelines." RF Safety Solutions. Web. 22 Oct. 2014. <http://www.rfsafetysolutions.com/RF%20Radiation%20Pages/ICNIRP_Guidelines.html>.

"ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz)." Health Physics 74.4 (1998): 494-522. International Commission on Non-Ionizing

Radiation Protection, 1998. Web. 22 Oct. 2014.
<http://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf>.

"ICNIRP Statement on the "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz)." Health Physics 97.3 (2009): 257-58. International Commission on Non-Ionizing Radiation Protection, 2009. Web. 22 Oct. 2014.
<http://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf>.

Juutilainen, Jukka, Anne Höytö, Timo Kumlin, and Jonne Naarala. "Review of Possible Modulation-dependent Biological Effects of Radiofrequency Fields." Bioelectromagnetics 32.7 (2011): 511-34. Web. 31 Oct. 2014. <http://www.ncbi.nlm.nih.gov/pubmed/21480304>.

Karaca, Emin, Burak Durmaz, Huseyin Aktug, Teoman Yildiz, Candan Guducu, Melis Irgi, Mehtap Gulcihan Cinar Koksal, Ferda Ozkinay, Cumhur Gunduz, and Ozgur Cogulu. "The Genotoxic Effect of Radiofrequency Waves on Mouse Brain." Journal of Neuro-Oncology. 107.3 (2012): 665. Web. 31 Oct. 2014. <http://www.ncbi.nlm.nih.gov/pubmed/2173207 >.

Katiyar, Sumit, R. K. Jain, and N. K. Agrawal. "R.F. Pollution Reduction in Cellular Communication." ArXiv.org. Cornell University Library. Web. 22 Oct. 2014.
<http://arxiv.org/ftp/arxiv/papers/1204/1204.2101.pdf>.

Kwon, Min Kyung, Joon Yul Choi, Sung Kean Kim, Tae Keun Yoo, and Deok Won Kim. "Effects of Radiation Emitted by WCDMA Mobile Phones on Electromagnetic Hypersensitive Subjects." Environmental Health 11.69 (2012). Environmental Health Journal, 21 Sept. 2012. Web. 22 Oct. 2014.
<http://www.ehjournal.net/content/11/1/69>.

Lowden, A., T. Akerstedt, M. Ingre, L. Hillert, N. Kuster, JP Nilsson, and B. Arnetz. "Sleep After Mobile Phone Exposure in Subjects with Mobile Phone-related Symptoms." Bioelectromagnetics 10.1002 (2011): 4-14. PubMed. Web. 22 Oct. 2014. <http://www.ncbi.nlm.nih.gov/pubmed/20857453>.

Mazar, Haim. "A Global Survey and Comparison of Different Regulatory Approaches to Non-Ionizing RADHAZ and Spurious Emissions." Ministry of Communications, RF Spectrum Department, Israel, 9 Nov. 2009. Web. 22 Oct. 2014. <http://www.moc.gov.il/sip_storage/FILES/6/1846.pdf>.

McKerracher, Colin, and Jacopo Torriti. "Energy Consumption Feedback in Perspective: Integrating Australian Data to Meta-analyses on In-home Displays - Springer." *Energy Efficiency* 6.2 (2013): 387-405. *Springer Link*. 10 Aug. 2012. Web. 15 Oct. 2014.
<http://link.springer.com/article/10.1007%2Fs12053-012-9169-3>.

Michaelson, Sol M. "Biological Effects and Health Hazards of RF and MW Energy: Fundamentals and Overall Phenomenology." Springer Link, 1983. Web. 3 Nov. 2014.
<http://link.springer.com/chapter/10.1007%2F978-1-4684-4253-3_15>.

Mohler, Evelyn, Patrizia Frei, Jurg Frohlich, Charlotte Braun-Fahrlander, and Martin Roosli. "Exposure to Radiofrequency Electromagnetic Fields and Sleep Quality: A Prospective Cohort Study." PLOS One 10.1371 (2012). 18 May 2012. Web. 22 Oct. 2014.
<http://www.plosone.org/article/info%253Adoi%252F10.1371%252Fjournal.pone.0037455>.

Mortazavi, Seyed, Ali Tavakkoli-Golpayegani, and Mohammad Mortazavi. "Looking at the Other Side of the Coin: The Search for Possible Biopositive Cognitive Effects of the Exposure to 900 MHz GSM Mobile Phone Radiofrequency Radiation." Journal of Environmental Health Science and Engineering 12.75 (2014). PubMed. Web. 22 Oct. 2014. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4004454/>.

Nave, R. "Microwave Ovens." *HyperPhysics: Electricity and Magnetism*. Georgia State University. Web. 13 Oct. 2014. <http://hyperphysics.phy-astr.gsu.edu/hbase/waves/mwoven.html>.

Poulsen, AH, S. Friis, C. Johansen, A. Jensen, P. Frei, SK Kjaer, SO Dalton, and J. Schuz. "Mobile Phone Use and the Risk of Skin Cancer: A Nationwide Cohort Study in Denmark." American Journal of Epidemiology 178.2 (2013): 190-97. PubMed. Web. 22 Oct. 2014. <http://www.ncbi.nlm.nih.gov/pubmed/23788669>.

National Aeronautics Space Agency. "Non-Ionizing Radiation Safety w/Change 1 (5/20/2014)" *Occupational Health Programs Manual – Chapter 10.* Cleveland: NASA, 2014. Web. 31 Oct. 2014 < http://smad-ext.grc.nasa.gov/shed/pub/ohpm/ohpm10.pdf>.

"Q&A: Wi-Fi Health Concerns." BBC News. BBC, 21 May 2007. Web. 15 Oct. 2014. <http://news.bbc.co.uk/2/hi/technology/6677051.stm>.

"Radio Frequency Radiation and Health: Smart Meters." Vermont Department of Health. February 10, 2012. <http://healthvermont.gov/pubs/ph_assessments/radio_frequency_radiation_and_health_smart_meters.pdf>

"Radiofrequency and Microwave Radiation." Safety and Health Topics. Occupational Safety & Health Administration (OSHA). Web. 23 Oct. 2014. <https://www.osha.gov/SLTC/radiofrequencyradiation/>.

"Radio Frequency Exposure Report." True North Associates and C2 Systems, Jan. 2013. Web. 23 Oct. 2014. <http://smartgridcc.org/wp-content/uploads/2013/08/RF-Report-Maine.pdf>.

"Radio Frequency Safety." *OET -- RF Safety FAQ's*. Federal Communications Commission, 25 June 2012. Web. 15 Oct. 2014. <http://transition.fcc.gov/oet/rfsafety/rf-faqs.html>.

"Radio Wave Attenuation at 2.4 GHz." *Moonblink*. Web. 15 Oct. 2014. <http://www.moonblink.com/store/attenuation_at_24ghz_.cfm>.

Ralph, Nate, and Kent German. "Cell Phones with the Highest Radiation Levels (pictures) - CNET." *CNET*. N.p., 9 June 2014. Web. 15 Oct. 2014. <http://www.cnet.com/pictures/highest-cell-phone-radiation/>.

Rivaldo, Alan. "Health and RF EMF from Advanced Meters: An Overview of Recent Investigations and Analyses." Public Utility Commission of Texas: Infrastructure & Reliability Division, Dec. 2012. Web. 23 Oct. 2014. <https://www.puc.texas.gov/industry/electric/reports/smartmeter/SmartMeter_RF_EMF_Health_12-14-2012.pdf>.

Roosli M. 2008. Radio Frequency Electromagnetic Field Exposure and Non-Specific Symptoms of Ill Health: A Systematic Review. Environmental Research 107: p 277-287.

Soper, Taylor. "Study: Americans Spend 162 Minutes on Their Mobile Device per Day, Mostly with Apps - GeekWire." *GeekWire*. 1 Apr. 2014. Web. 13 Oct. 2014. <http://www.geekwire.com/2014/flurry-report-mobile-phones-162-minutes/>.

Swerdlow, Anthony J., and Maria Feychting. "Mobile Phones, Brain Tumors, and the Interphone Study: Where Are We Now?" Environmental Health Perspectives 119.11 (2011): 1534-538. PubMed. Web. 22 Oct. 2014. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3226506/>.

Tell, Richard A., and Christopher A. Tell. "An Evaluation of Radio Frequency Fields Produced by Smart Meters Deployed in Vermont." Richard Tell Associates, 14 Jan. 2013. Web. 23 Oct. 2014. <http://www.fpl.com/energysmart/pdf/vermont.pdf>.

"Transmissions Standards for FM Sound Broadcasting at VHF." *ITU: Committed to Connecting the World*. 2001. Web. 15 Oct. 2014. <http://www.itu.int/dms_pubrec/itu-r/rec/bs/R-REC-BS.450-3-200111-I!!PDF-E.pdf>.

Vanderlinden, Loren, and Ronald Macfarlane. "Update and Review of Research on Radiofrequencies: Implications for a Prudent Avoidance Policy in Toronto." Toronto Public Health. Nov. 2007. Web. 22 Oct. 2014. <http://www1.toronto.ca/city_of_toronto/toronto_public_health/healthy_public_policy/hphe/files/pdf/technical_report.pdf>.

Verschaeve, L., J. Juutilainen, I. Lagroye, J. Miyakoshi, R. Saunders, R. De Seze, T. Tenforde, E. Van Rongen, B. Veyret, and Z. Xu. "In Vitro and in Vivo Genotoxicity of Radiofrequency Fields." Mutation Research/Reviews in Mutation Research 705.3 (2010): 252-68. Web. 31 Oct. 2014. <http://www.ncbi.nlm.nih.gov/pubmed/20955816>.

Vinogradov, G.I., G.M. Naumenko, E.M. Vinarskaya, and N.M. "Biological Significance of Autoimmune Reactions of the Organism After Exposure to Environmental Factors." Gig Sanit 1:55-58.

Ziskin, Marvin. "COMAR Technical Information Statement: The IEEE Exposure Limits for Radiofrequency and Microwave Energy." Institute of Electrical and Electronics Engineers (IEEE), Apr. 2005. Web. 23 Oct. 2014. <http://ewh.ieee.org/soc/embs/comar/standardsTIS.pdf>

Appendices

Appendix A: Health Concerns Mentioned in Submissions to the ACC eDocket

Health Concerns Mentioned in Submissions to the ACC eDocket		Number of times mentioned
Top Five Concerns	Headaches	28
	Insomnia	27
	Cancer	15
	Fatigue	14
	Ear pain/hearing	14
Other Health Concerns Mentioned	Difficulty concentrating/brain damage	12
	Heart problems/palpitations	12
	Agitation/Anxiety	11
	Depression	8
	Dizziness	8
	Nausea	7
	Muscle pains	6
	Hay fever/allergies	5
	Chest pain	5
	Seizures	5
	Shortness of breath	4
	High blood pressure	4
	Skin rashes	4
	Sperm production	3
	Autoimmune diseases	3
	Memory loss	3
	Confusion	3
	Shaky hands	2
	Nervous system issues	2
	Autism	2
	Fibromyalgia	1
	Hair loss	1
	Sore throats	1
	Miscarriage	1
	Birth defects	1
	Eye problems	1

	Diarrhea	1
	High blood sugar	1
	Nose bleed	1
	Mutation	1
	Jaw pain	1
	Digestion problems	1
	Stroke	1
	Back pain	1
	Total Number of Health Concerns	**164**

Appendix B: Review of Submitted Articles

ADHS reviewed the articles submitted by concerned citizens related to potential health effects from the RF radiation produced by smart meters. The main points from the most cited articles are listed below, and ADHS's response is provided:

1. Article: "Electromagnetic and Radiofrequency Fields Effect on Human Health." The American Academy of Environmental Medicine (AAEM). 2008.

   Main Points Stated by the Article:

   - In the last 20 years, physicians began seeing patients who reported that electric power lines, televisions, and other electrical devices caused a wide variety of symptoms.
   - Multiple studies correlate RF exposure with diseases such as cancer, neurological disease, reproductive disorders, immune dysfunction, and electromagnetic hypersensitivity.
   - Exposure limits determined by the FCC and other regulatory agencies do not account for effects from non-thermal radiation.

   ADHS's Response: AAEM are not recognized by the American Board of Medical Specialties.

2. Article: Loren Vanderlin. "Update and Review of Research on Radiofrequencies: Implications for a Prudent Avoidance Policy in Toronto." Toronto Public Health. November 2007.

   Main Points Stated by the Article:

   - Despite limitations in the body of research to date, the possibility of harmful health effects from RF exposures cannot be ruled out.
   - Studies of the impacts on children from cell phone RFs, while limited in number, do not rule out the possibility that children require greater protection from RF exposure.
   - Research in populations near cell phone base stations in Europe indicates that some people living within about 300 meters of a base station are more likely to experience symptoms, such as headache, memory changes, dizziness, tremors, depression, and sleep disturbance.
   - In the face of uncertain risks, prudent avoidance is still the best approach to minimize public exposure from the new and increasing number of RF sources.
   - In response to this article, Toronto Public Health (TPH) reviewed the predicted RF values **provided by companies applying to install new cell phone base stations in Toronto and** requested that providers keep RF emission levels 100 times below Safety Code 6, Health Canada's public exposure guideline. **From its review of recent health evidence, TPH notes that the majority scientific opinion indicates that the health risk to the public from** cell towers and other telecommunications sources of RFs is low.

   ADHS Response: Although this article infers the biological feasibility of RF exposure and non-thermal effects, this article does not directly relate to the goals of this review. ADHS focused on

RF exposures in the home. RF exposure at or near cell towers tend to be at much higher power densities than that which are measured near electronic meters, and is therefore not within the scope of this report.

3. Article: Andrew Goldsworthy. "The Biological Effects of Weak Electromagnetic Fields – Problems and Solutions." March 2012.

   Main Points Stated by the Article:

   - Weak electromagnetic fields from cell phones, cordless phones, and WiFi can have serious effects on human and animal health. These include damage to glands resulting in obesity and related disorders, chronic fatigue, autism, increases in allergies and multiple chemical sensitivities, early dementia, DNA damage, loss of fertility, and cancer.
   - The frequencies that give damaging biological effects lie between 6Hz and 600Hz. Virtually all digital mobile telecommunications systems use pulses within this range.
   - Until the mobile telecommunications industry makes its products more biologically friendly, we have little alternative but to reduce our personal exposure as far as possible by using cell phones only in emergencies, avoiding cordless phones, and substituting WiFi with Ethernet.
   - This article is only one of many included in the FCC's electronic comment filing system. To arrive at its guideline, the FCC considers a large number of comments submitted by industry, government agencies, and the public. The radiation emitted from smart meters is well below the FCC standard.

   ADHS Response: This article references RF between 6 Hz and 600 Hz. However, the range of RF is actually 3KHz to 3GHz. EMF in the range of 6 Hz and 600 Hz is actually Extremely Low Frequency (1-300Hz) and Intermediate Frequency (IF) Fields (300 Hz – 10 MHz). This review focused on RF and did not research the potential health effects of ELF or IF.

Appendix C: Field Sampling Form

Meter Sampling Checklist

Name of technician:_____ RF Sampling Device:_____/ Calibration Date:_____

Please circle one for each option:

Single Family Home or Apartment Complex	Urban Area or Rural Area	Single meter or Multiple meters (# of meters:_____)

Background reading in the shade:_____ Background reading in the sun:_____

Address:_____ Location of meter on home: garage or living space
Meter Model:_____

Time period:		Sample Time 1		Sample Time 2		Sample Time 3	
Weather Condition (circle one):		Sunny ¦ Partly Cloudy ¦ Mostly Cloudy		Sunny ¦ Partly Cloudy ¦ Mostly Cloudy		Sunny ¦ Partly Cloudy ¦ Mostly Cloudy	
Reading Taken in Shade (Yes/No)		Yes ¦ No		Yes ¦ No		Yes ¦ No	
Date and Time:							
Readings		Average	Max	Average	Max	Average	Max
Distance 1 foot	Measurement 1: (at 5 min)						
	Measurement 2: (at 10 min)						
	Measurement 3: (at 15 min)						

Comments:

Address:_____ Location of meter on home: garage or living space
Meter Model:_____

Time period:		Sample Time 1		Sample Time 2		Sample Time 3	
Weather Condition (circle one):		Sunny ¦ Partly Cloudy ¦ Mostly Cloudy		Sunny ¦ Partly Cloudy ¦ Mostly Cloudy		Sunny ¦ Partly Cloudy ¦ Mostly Cloudy	
Reading Taken in Shade (Yes/No)		Yes ¦ No		Yes ¦ No		Yes ¦ No	
Date and Time:							
Readings		Average	Max	Average	Max	Average	Max
Distance 1 foot	Measurement 1: (at 5 min)						
	Measurement 2: (at 10 min)						
	Measurement 3: (at 15 min)						

Comments: